Mathematicks made Plain,
In the Solution of Variety
Of Uſeful Propoſitions

IN

Arithmetick.
Intereſt, Simple and Compound.
Geometry.
Surveying.
Gauging.
Meaſuring all Artificers Works.
Trigonometry, Plain and Spherical.
Aſtronomy.
Geography.

Navigation.
Dialling.
Chronology.
Dioptricks.
Staticks.
Gunnery.
Military Fortification.
Civil and Naval Architecture.
Mechanick Powers.
Automaticks, or Clock-Work, &c.

All Perform'd by that Excellent *Line of Numbers*, commonly call'd *Gunter's-Line.*

BEING

A neceſſary Companion for Gentlemen, Military Officers, Engineers, Architects, Seamen, Surveyors, Uſurers, Shopkeepers of all ſorts; Artificers, as Maſons, Bricklayers, Carpenters, Shipwrights, Watch-makers, Glaziers, Painters, Plaiſterers, *&c.*

By *Richard Neve*, Philomath.

Approv'd of by the Royal Society.

London: Printed by *W. Pearſon*, for *G. Conyers*, *J. Sprint*,
and *T. Ballard*, all in *Little-Britain*. 1708. Pr. 2 s.

BRITISH MUSEUM
30 DEC 60

To the Worſhipful

JOHN FULLER

OF

rightling in the County of *Suſ-ſex*, Eſq; one of Her Majeſties Juſtices of the Peace for the ſaid County.

Worthy Sir,

I *Am bound in Gratitude, to preſent you with this* Abridgment f Practical Mathematicks; *and hat for theſe particular Reaſons. irſt, Becauſe, upon ſight of the opy of this Book, your Worſhip as pleaſed to ſhew it to the* Roy- Society, *and from them to bring e their* Approbation *of it. Se- ndly, Becauſe, you are a gene- l incourager of all Ingenious Studies.*

dies. And, Thirdly, Because you have expreſt a particular Reſpect to me by your many Civilities; notwithſtanding I was an abſolute Stranger to your Worſhip, till within theſe few Months. And therefore I think my ſelf bound to an humble Acknowledgment of your Favours; which, Sir, if you will accept this *as a Token of, it wil yet more Oblige him, who is already,*

Your Worſhip's

Moſt Humble, and

Moſt Obliged Servant,

Richard Neve

BRITISH MUSEUM 30 DEC 60

TO

TO THE
READER:

THE following Sheets have been ſeen by ſeveral of my Friends, who judged them fit for the Publick; what the reſt of the World may think of them, I know not, for I know there are a ſort of Men in the World, that are readier to *find* Faults than to mend them; to *ſuch*, I ſhall only offer that of the Poet,

Carpare vel noli Noſtra, vel ede tua.

Or as it may be Engliſhed,

Either commend me, or come and mend me.

The Preface.

I am not ignorant, that many good Authors have already treated of this Subject; as Mr. *Gunter*, Mr. *Wingate*, Mr. *Collins*, Mr. *Oughtred*, Mr. *Patridge*, Mr. *Leybourn*, Mr. *Brown*, and others, too many to mention here; and therefore what I have here done may ſeem altogether Superfluous: But let me add, That many of theſe Authors have treated only occaſionally of this amongſt other Subjects; whereby their Volumns are rendred too large for the Pocket, and therefore (unleſs a Man can carry all their Rules in his Head) they loſe the *End* for which *this* was compos'd.

Again, ſome of theſe Authors have treated of the Line of Numbers as apply'd to Circles, or Quadrants, or to ſlide one by another: In theſe Caſes a Man muſt have thoſe particular Inſtruments, otherwiſe nothing is to be done.

'Tis true, ſome of theſe Authors have treated of it (as I have done) as 'tis commonly made on the Carpenters Rule, to be us'd with Compaſſes: And what they have done, they have done well enough; only they have enlarged too much upon *ſome* Particulars, whereby they were forced to omit *others* as uſeful; and ſo could not ſufficiently diſplay the Excellency of the Line.

Having thus far ſhewn what has been done by *others*, give me leave to tell thee what I have (here) done my ſelf.

Firſt then, I have (in the following Sheets) ſhewn how (with a common Carpenters Rule, and a pair of Compaſſes) to ſolve all the moſt uſual and moſt uſeful Propoſitions, in all theſe Arts and Sciences mention'd above in the Title Page.

The Number of Propoſitions, contain'd in this Book, are almoſt incredible, amounting to near *Seventeen Thouſand*, which is perhaps almoſt 100 times as many, as ever was mentioned by any of (or all) the other Authors that have treated of this Subject: And yet I dare preſume boldly to affirm, That there is not one of them all, but what is (*here*) made as intelligible, (even to the meaneſt Capacity, that has but learnt the Terms of Art,) as by any other Author.

The Preface.

I have taken a great deal of Pains, to Comprize ſo much in ſo little Compaſs; (for thou haſt here an Epitome of the whole Practical Mathematicks; and in order to this, I have Calculated ſeveral Hundreds of fixed Numbers, which may ſerve as Centers on the Line, for the more eaſy and expeditiouſly Solving of many Problems.

A particular Account of all that is contain'd in this Treatiſe may be ſeen in the Proeme to each Book.

The whole is compris'd in ſo brief, and yet ſo plain a Method, that I think I may boldly affirm, *The like* (*of this Nature*) *was never before extant.* And let me add, That he that has this Book in his Pocket, (together with a common Carpenters Rule and a pair of Compaſſes) may ſolve almoſt all Propoſitions in the Mathematicks, with great eaſe and expedition, and ſufficient Accuracy. I ſhall only add,

Reader, the Printer's Faults are none of mine,
Correct the Errors, elſe the Fault is thine.

Et ſic Vale.

THE

THE CONTENTS.

BOOK I.

Page
CHap. 1. *Of Numeration on the Line* 1
Chap. 2. *Of Multiplication by the Line* 6
Chap. 3. *Of Diviſion* 7
Chap. 4. *Of Reduction* 8
Chap. 5. *Of Progreſſion* 21
Chap. 6. *Of the Golden-Rule Direct* 24
Chap. 7. *Of the Golden-Rule Reverſe* 28
Chap. 8. *Of the double Rule of Three* 34

Chap. 9. *Of the Rule of Fellowſhip* 36
Chap. 10. *Of the Rules of Practice* 38
Chap. 11. *Of the Extraction of the Square Root* 39
Chap. 12. *Of the Extraction of the Cube Root* 40
Chap. 13. *Of Intereſt and Annuities* 42
Chap. 14. *Of Military Affairs* 46
Chap. 15. *Of Duplicate Proportion* 51
Chap. 16. *Of Triplicate Proportion* 56

BOOK II.

CHap. 1. *Of Menſuration of Lines* 62
Of Altimetry and Longimetry, or taking Heights and Diſtances 76
Chap. 3. *Of Planimetry, or the Menſuration of Superficial Figures* 87
Chap. 4. *Of Plano-Steriometry, or the Menſuration of the Superficiality of Solid Bodies.* 98
Chap. 5. *Of Steriometry, or the Menſuration of Solids* 103

Chap.

Chap. 6. *Of the Menſuration of Artificers Work* 116
Chap. 7. *Of Staticks, or finding the Gravity of Bodies* 134
Chap. 8. *Of Gauging* 160

BOOK III.

CHap. 1. *Of Trigonometry* 176
Chap. 2. *Of Right-Angl'd Plain Trigonometry* 185
Chap. 3. *Of Oblique-Angl'd Plain Trigonometry.* 187
Chap. 4. *Of Right-Angl'd Spherical Trigonometry* 189
Chap. 5. *Of Oblique-Angl'd Spherical Trigonometry* 191
Chap. 6. *Of Aſtronomy.* 194
Chap. 7. *Of Geography* 205
Chap. 8. *Of Navigation* 207
Chap. 9. *Of Dialling.* 21

BOOK

BOOK IV.

Chap. 1. *Of Chronology* 219
Chap. 2. *Of Dioptricks* 229
Chap. 3. *Of Gunnery* 237
Chap. 4. *Of Fortification* 243
Chap. 5. *Of Architecture* 246
Chap. 6. *Of Nautical Architecture* 251
Chap. 7. *Of Mechanic Powers* 256
Chap. 8. *Of Automaticks or Clock-Work* 265
Chap. 9. *Of Philoſophy* 272

BRITISH MUSEUM
30 DEC 60

MATHE-

MATHEMATICS
Made plain,
the Solution of Variety of Uſeful Propoſitions in *Arithmetick*, &c.

BOOK I.
Of the Uſe of the Line of Numbers in Arithmetick.

PROEME.

Shall not here inſiſt upon the making of the Line of Numbers; that being a thing ſo well known to all Mathematical Inſtrument Makers; (and any e elſe may buy them cheaper than he can make them mſelf;) but ſhall haſten to ſhew the Excellency and ſefulneſs of it.

CHAP. I.
Of Numeration on the Line of Numbers.

N*Umeration* is the Art of reading Numbers; *i. e.* of relating the true Value of any Number, as it is ex-eſt, either by proper Characters or Figures, as in Figu-tive Arithmetick; or by Diviſions and Subdiviſions, as our preſent Caſe of Inſtrumental Arithmetick.

Therefore, in order to teach the Art of Numeration the Line, it will be neceſſary to ſhew how, or in hat manner the Line is divided and numbred; as alſo hat thoſe Diviſions and Numbers ſet to them upon e Rule, do ſignify.

Know therefore, that at the Beginning of the Line, there is ſet the Figure 1; and ſo proceeding ſucceſſively from 1 to 2, 3, 4, 5, 6, 7, 8, 9, to 1 again in the Middle of the Line; from whence it proceeds in the ſame Order to the other End, where it ends with 10.

The Reaſon why the Line is numbred only with Digits, is, that by prefixing or affixing of Cyphers to thoſe Digits, it might be capable to expreſs differen Numbers, as there may be occaſion, according to th Nature of the Queſtion.

Thus, ſometimes the 1, at the Beginning of th Line, ſignifies 1 only, and then the 1 in the Middl ſignifies 10, and the 1 at the other End 100.

Again, If 1 at the Beginning denotes 10, then in the Middle is 100, and 1 at the End, 1000. S that for any Number between 10 and 1000, the F gures very readily direct you.

Again, If 1 at the Beginning be $\frac{1}{10}$ of an Integer, then 1 in the Middle is 1 Integer, and 1 at th End is 10.

Again, If 1 at the Beginning be $\frac{1}{100}$ of an Integer, then 1 in the Middle is $\frac{1}{10}$ of an Integer, an 1 at the End is 1 Integer.

Note alſo, That, as the whole Line is divide into 100 Parts, ſo is each of thoſe Parts ſubdivide into 10 Parts more, or as the Length thereof wi permit, more or leſs, in a Decuple or Ten-fold Order and every 5th of the Grand Intermediate Diviſio is drawn longer than the reſt, for Eaſe in counting This being premis'd, I proceed to ſhew in

PROP. I.

How to find the Point on the Line repreſenting any giv Number.

The RULE.

How many Places ſoever your Number is of; fo the firſt Figure of your Number, take the ſame Figu

o

n the Line: for the ſecond Figure of your Number, ake the Number thereof on the grand (or longer) ntermediate Diviſions on the Line: for the third Figure f your Number, take the Number thereof on the ſmaller Intermediate Diviſons; and the place of the ourth (fifth, &c. if you have more) muſt be found y Eſtimation.

Note, By the firſt, ſecond, third, &c. Figure, is meant the firſt, ſecond, third, &c. Figure, from the Left Hand towards the Right. This being known, the Precept is plain, and needs no Example: yet, becauſe he Learner ought to be very perfect in this Propoſition, ſhall here give him one or two Examples.

Example 1.

Let it be requir'd to find the Place of 144 on the ine. For your firſt Figure 1, count the 1 in the Middle of the Line; for your ſecond Figure 4, count 4 of he Grand Diviſions, betwixt the Figures 1 and 2, on he Line; and for your third Figure 4, count 4 of the ſmalleſt Intermediate Diviſions; and that very Point is he Place upon the Line repreſenting 144.

Example 2.

Let it be requir'd to find the Place of 1728 on the ine. For your firſt Figure 1, take 1 in the Middle of he Line; for your ſecond Figure 7, take 7 of the Grand-Diviſions; for your third Figure 2, take 2 of the ſmaller ntermediate Diviſions; and for your fourth Figure 8, ake (by Eſtimation) 8 tenth Parts [that is a little better than three quarters] of one of the next of thoſe ſmaller Intermediate Diviſions; and that is the Place of 1728.

Now, by theſe two Examples, you may perceive, hat the Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, do vary their ignification, according to the Nature of the Queſtion. And by this Variation and Change of the Powers of heſe Numbers, from 1 to 10, 100, or 1000, &c. any roportion, either Arithmetical or Geometrical, may

be wrought; one whereof I will here inſert, (for yo
better Exerciſe of Numbring on the Line; by the ofte
practice whereof, you will find the Work to be faci
and delightful;) which ſhall be this following.

PROP. II.

Having two Numbers given, to find as many more as y
pleaſe, in continual Proportion one to another, as the t
given Numbers were.

The RULE.

Place one Foot of the Compaſſes in the firſt giv
Number on the Line, and extend the other to the ſecon
given Number; then may you turn the Compaſſes (t
ſame way) from that ſecond Number to a third; fro
that third to a fourth, *&c.* to as many as you plea
But when the Compaſſes run off the Line, place the
on again at the ſame Number (they were at when th
ran off) at the other End of the Line.

Example 1.

Let the two given Numbers be 1 and 2; Place o
Foot of your Compaſſes in 1, and extend the oth
Foot to 2; then the Compaſſes being turn'd about, w
reach from 2, to 4; and from 4, to 8; and from 8,
16; and from 16, to 32, *&c.*

Example 2.

If the two given Numbers were 10 and 9, decreaſin
then the Extent of the Compaſſes from 10, to 9, w
reach from 9, to 8. 1; and from thence to 7. 29; a
from thence to *6. 56, &c.*

Becauſe the Line of Numbers is ſometimes very
ronioſly made, it will not perhaps be altogether imp
tinent, if (before I conclude this Chapter) I inſert t
following Propoſition.

PROP. III.

To find whether the Line of Numbers be truely made, or not.

To do this, take a very ſharp-pointed Pair of Compaſſes, and extend their Points (as nicely as you can) from 1, to 2, on the Line; then turning the Compaſſes about, they ſhall (if the Line be truely made) reach from 2, to 4; and from 4, to 8; and from 8, to 16; and from 16, to 32; and from 32, to 64, *&c.*

Alſo, the ſame Extent of the Compaſſes ſhall reach exactly (if the Line be truely made) from 1.5, to 3, and from thence to 6, and from thence to 12, and from thence to 24, and from thence to 48, and from thence to 96, *&c.*

Again, the ſame Extent of the Compaſſes ſhall reach exactly (if the Line be truely made) from 2.5, to 5; from 5, to 10; from 10, to 20; from 20, to 40; and from 40, to 80, *&c.*

Likewiſe, the ſame Extent of the Compaſſes ſhall reach exactly (if the Line be truely made) from 3.5, to 7; from 7, to 14; from 14, to 28; and from 28, to 56, *&c.*

In like manner, the ſame Extent of the Compaſſes ſhall reach exactly (if the Line be truely made) from 4.5, to 9; from 9, to 18; from 18, to 36; and from 36, to 72, *&c.*

Or, you may extend the Compaſſes from 1, to 3, and then (if the Line be truely made) that Extent ſhall reach (exactly) from 3, to 9; from 9, to 27; and from 27, to 81, *&c.*

By theſe and ſuch like Ways, you may eaſily try whether or no your Line of Numbers be exactly made.

CHAP. II.

Multiplication by the Line.

M*Ultiplication* is the next Rule, in the Order of our Inſtrumental Arithmetick; becauſe Addition and Subſtraction can't be wrought by the Line of Numbers.

Multiplication is a Rule, by which we find the Increaſe or Amount of any Number, being ſo many times taken as there are Units in another Number: and this Increaſe or Amount is call'd the Product; and the two Numbers producing it are call'd the Factors.

The Reader is here to Note, That almoſt all Operations on the Line of Numbers, are but the working ſo many Analogies or Proportions: And therefore if any thing ſeem difficult to the Learner, (either in this or the three following Chapters) let him conſult Chap. VI. of this Book. This being premis'd, I come to ſhew how to perform Multiplication by the Line. To do which, this is

The ANALOGY.

As 1, to any one of the Factors; ſo is the other Factor, to the Product.

Therefore,

Extend the Compaſſes from 1, to any one of the Factors; (or Numbers to be Multiply'd;) and the ſame Extent of the Compaſſes, will reach (being apply'd the ſame way) from the other Factor, to the Product.

Example.

Let it be requir'd to multiply 19 by 5. Here, the Extent from 1 to 5, will reach from 19 to 95, the Product ſought.

This is too plain to need another Example. And here let me inform the Reader, That I ſhall be cautious (throughout this whole Book) how I multiply needleſs

Examples, not only (tho chiefly) for Brevity ſake, but becauſe any one may frame Examples at his pleaſure, which he may prove with his Pen. Therefore I ſhall only add two or three Notes, and ſo conclude this Chapter.

Note 1. It matters not where you take your *One*, whether at the Beginning or Middle of the Line; Or, if your Compaſſes be too ſhort to reach *forward* from 1, at the Beginning or Middle of the Line, you may extend them *backward* from 1, at the Middle or End: provided that you know what Denomination to give to your Product; which you may do by

Note 2. The Product always contains ſo many Figures as are contain'd in both the Factors; unleſs the two firſt Figures (from the Left towards the Right) of the Product be greater than the two firſt Figures of any of the Factors; for if ſo, the Product muſt have one Figure leſs than is contain'd in both the Factors.

Note 3. If the Compaſſes run off the Line; Note the Point they ſtood at when they ran off; and ſet them on again at a like Point in the other Radius of the Line. This Note ought to be well underſtood, it being of general Uſe in all Propoſitions, wherein the Compaſſes may happen to run off the Line.

CHAP. III.

Diviſion by the Line.

D*iviſion* is a Rule by which we diſcover how many times one Number (call'd the Diviſor) may be had in another (call'd the Dividend,) and the Anſwer found is call'd the Quotient. To work this by the Line, this is

The ANALOGY.

As the Diviſor, is to the Dividend; ſo is 1, to the Quotient.

Or,

As the Diviſor, is to 1; ſo is the Dividend, to the Quotient.

Therefore,

The Extent of the Compaſſes from the Diviſor to $\left\{\begin{matrix}\text{the Dividend}\\ \text{Unity}\end{matrix}\right\}$ will reach (being apply'd the ſame way) from $\left\{\begin{matrix}\text{Unity}\\ \text{the Dividend}\end{matrix}\right\}$ to the Quotient, in Whole Numbers and Decimal Fractions, if the Quotient be ſmall; but if the Quotient exceed 20 or 30, you will hardly diſtinguiſh it nearer than to Whol Numbers only.

Example 1.

Let it be requir'd to divide 77 by 4. Here, the Extent of the Compaſſes from 4 to 1, will reach (the ſame way) from 77 to 19,25; that is, $19\frac{1}{4}$ the Quotien ſought.

Example 2.

Let it be requir'd to divide 240, by 15. Here, th Extent from 15 to 1, will reach from 240 to 16, th Quotient ſought.

What has been ſaid, together with the following Notes being well read and practiſed, is ſufficient to make thi Rule plain to the meaneſt Capacity.

Note 1. It matters not where you take your *One* whether at the Beginning, or Middle of the Line: O if your Compaſſes be too ſhort to reach backward to 1 at the Beginning or Middle of the Line; you may ex tend them forward to 1, at the Middle or End of th Line; provided that you know what Denominatio to give to your Quotient: Which you may know b the following Note.

Note 2. The Number of Figures in the Quoti is always ſo many as the Figures of the Dividend excee the Figures of the Diviſor; and one more when the tw firſt Figures of the Dividend are greater than the two fir Figures of the Quotient.

CHA

CHAP. IV.

Reduction by the Line.

REduction is a Rule, that teaches how to bring a Number from one Denomination to another.

PROP. I.

To reduce any Greater Denominations into Leſſer Denominations.

The ANALOGY.

As 1, to the Number of thoſe Leſſer Denominations contain'd in one of the Greater Denominations; ſo is the Number of thoſe given Greater Denominations, to the Number of thoſe Leſſer Denominations equivalent thereunto.

Example.

In 20*l.* how many Shillings? Anſ. 400. For, as 1 : 20 : : 20 : 400. In the ſame manner 20 Perches, will be found to be 110 Yards. For as 1 : $5\frac{1}{2}$: : 20 : 110. And ſo of all other Denominations, whether they be Weight, Meaſure, Time, or the like.

PROP. II.

To reduce any Leſſer Denominations into Greater Denominations.

This is but the Converſe of the former Propoſition; and therefore to ſolve it, this is

The ANALOGY.

As the Number of thoſe Leſſer Denominations that make one of thoſe Greater Denominations, is to 1; ſo is the given Number of thoſe Leſſer Denominations, to the Number of thoſe Greater Denominations equivalent thereunto.

Example.

In 400 Shillings, how many Pounds? Anſ. 20. For, as 20 : 1 :: 400 : 20. Again, In 110 Yards, how many Perches? Anſ. 20. For, as $5\frac{1}{2}$: 1 :: 110 : 20.

PROP. III.

To reduce a Fraction from one Denominator to another.

The ANALOGY.

As the Given Denominator, is to his Numerator; ſo is the Intended Denominator, to his Numerator.

Example.

What part of 20, is $\frac{3}{12}$? Anſ. $\frac{5}{20}$? For, as 12 : 3 :: 20 : 5.

PROP. IV.

To reduce a Vulgar Fraction to a Decimal Fraction.

The ANALOGY.

As the Denominator of the Given Fraction, is to his Numerator; ſo is 1 (at the Middle or End of the Line), to the Decimal Fraction requir'd.

Example.

What is $\frac{3}{12}$, being reduc'd to a Decimal Fraction? Anſ. .25. (*i. e.* 2 Primes, 5 Seconds.) For, as 12 : 3 :: 1 : .25.

PROP. V.

To reduce Moneys, Weights, Meaſures, &c. into Decimals.

To do this, Obſerve, that the greateſt Denominations of Moneys, Weights, *&c.* are commonly counted Integers: this known, the Decimal of any ſmaller Denominations are found by this

RULE.

Conſider what Vulgar Fraction your given Weights, Moneys, *&c.* are of an Integer; and by Prop. IV. reduce that Vulgar Fraction to a Decimal.

Example.

What is the Decimal of 5 *s.*? Anſ. In conſideration that Pounds are the greateſt Denominations of Moneys; therefore one Pound is the Integer: then becauſe 5 *s.* is $\frac{5}{20}$ of a Pound, I reduce $\frac{5}{20}$ (by Prop. IV.) into a Decimal, and it brings me .25, which is the Decimal (of a Pound) anſwering to 5 *s.*

By the ſame Method, the Decimal (of a Foot) anſwering to 9 Inches, will be found to be .75. And ſo of any other Moneys, Meaſures, Weights, Times, or the like.

PROP. VI.

To reduce a Decimal Fraction to a Vulgar Fraction.

This Propoſition is but the Converſe of the 4th. And therefore to ſolve it, this is

The RULE.

As 1 (at the Middle, or End of the Line), is to the Given Decimal; ſo is the Given Denominator, to his Numerator. So this Decimal .75 of a Gallon, will be found to be $\frac{6}{8}$, that is, 6 Pints.

PROP. VII.

To reduce a Decimal to his known Parts of Coyn, Weight, Meaſure, &c.

The RULE.

As 1 (at the Middle, or End of the Line), is to the Given Decimal; ſo is the Number of Parts that make an Integer, to the Number of thoſe Parts equivalent to the Given Decimal.

Example.

What is the Value of this Decimal .125 of a Pound? Anſ. 2 *s.* 6 *d.* For as 1 : .125 : : 20 *s.* 2.5 *s.* *i. e.* 2 *s.* and .5 of a Shilling. Then, as 1 : .5 : : 12 *d.* 6 *d.*

Thus .125 of a Foot, will be found to be $1\frac{1}{2}$ Inch. And ſo of any other Denominations.

PROP.

PROP. VIII.

To reduce a Whole Number to an Improper Fraction.

The ANALOGY.

As 1, to the Given Number; ſo is the Intended Denominator, to his Numerator.

So, if 2 were requir'd to be reduc'd to an Improper Fraction, whoſe Denominator ſhould be 3; it would be found to be $\frac{6}{3}$. And ſo of any other Number.

PROP. IX.

To reduce an Improper Fraction to its equivalent Whole, or Mixt Number.

The ANALOGY.

As the Denominator of the Given Fraction, is to his Numerator; ſo is 1, to his equivalent Whole, or Mixt Number.

Thus Working, you will find $\frac{6}{3}$ to be equal to 2, and $\frac{10}{4}$ to be equal to 2.5; *i. e.* $2\frac{1}{2}$. and ſo of others.

PROP. X.

To reduce a Compound Fraction to a Simple One of the ſame Value.

The RULE.

If the Compound Fraction conſiſt but of two Fractions; then ſay, As the Numerator of one of the Fractions, is to his Denominator; ſo is the Denominator of the other Fraction, to a new Denominator, to his former Numerator: Which new Fraction is equal to the Compound Fraction given.

Thus $\frac{1}{4}$ of $\frac{1}{4}$ will be found to be equal to $\frac{1}{16}$.

But if the Compound Fraction conſiſt of three (or more) Fractions; then find a Simple Fraction equal to any two of them, as before; and ſay, As the

Numerator of this New Fraction, is to his Denomina-or; ſo is the Denominator of one of the reſt of the ractions, to a new Denominator to their Fraction; hereby making him equal to them three. Then, if the Compound Fraction conſiſt of more Fractions, ſay (as efore) As the Numerator of *this* New Fraction, is to is Denominator; ſo is the Denominator of one of the eſt of the Fractions, to a new Denominator to that raction; thereby making him equal to (the Compoſi-ion of) them four. Proceed in the ſame manner if here were more Fractions in the given Compound raction.

Example.

What is the Value of $\frac{1}{3}$ of $\frac{2}{4}$ of $\frac{2}{6}$ of $\frac{3}{6}$? Anſ. $\frac{3}{108}$. For, as 1 : 3 :: 4 : 12. then, as 2 : 12 :: 6 : 36. then, s 2 : 36 :: 6 : 108, the Denominator to 3, the laſt Numerator.

Here, Note. It is the beſt way to leave that Fraction ill laſt, which has the leaſt Numerator; for ſo the imple Fraction will be in the leſſer Terms So, if (in his Example) we had left the $\frac{1}{3}$ till laſt, it would have een brought to $\frac{1}{36}$.

PROP. XI.

To reduce a Fraction to ■ *leaſt Terms.*

The RULE.

Extend the Compaſſes from the Numerator of the Given Fraction, to his Denominator; then apply that Extent, the ſame way, from 1, 2, or 3, or what other Number you can find will make the other Foot of the Compaſſes reſt in a Whole Number; for then the leſſer f thoſe two Numbers where the Compaſſes reſt, is the Numerator, and the greater is the Denominator of the raction reduc'd to his leaſt Terms.

Thus $\frac{12}{24}$ will be found equal to $\frac{1}{2}$, and $\frac{24}{36}$ will be und equal to $\frac{2}{3}$.

PROP. XII.

To reduce Foreign Weights and Meaſures into Engliſ *ones; and the contrary.*

To ſolve this Propoſition, take the following Table and the Rules following them.

1. *A TABLE, carefully comparing Foreign Weigh and Meaſures with the* Engliſh.

Places Names.	Feet 1000 Parts	Pounds 100 Part
London Foot.	1. 000	
London Pound Averd.	- - -	1. 00
France.		
Paris Royal Foot.	1. 068	0. 93
Lyon Ell.	3. 976	1. 09
Bologn Ell.	2. 076	0. 89
XVII Provinces.		
Amſterdam Foot.	0. 942	0. 93
Amſterdam Ell.	2. 269	
Antwerp Foot.	0. 946	0. 98
Antwerp Ell.	2. 273	
Brill Foot.	1. 103	
Dert Foot.	1. 184	
Leyden or *Rynland* Ell.	1. 033	0. 96
Leyden or *Rynland* Ell.	2. 260	
Lorain Foot.	0. 958	0. 98
Mecklin Foot.	0. 919	0. 98
Middleburg Foot.	0. 991	0. 98

Ger

Places Names.	Feet	1000 Parts	Pounds	100 Parts
Germany.				
Strasburg Foot.	0.	920	0.	93
Bremen Foot.	0.	964	0.	94
Cologn Foot.	0.	954	0.	97
Frankford (on the *Main*) Foot.	0.	948	0.	93
Frankford (on the *Main*) Ell.	1.	825		
Hamborough Ell.	1.	905	0.	95
Leipſic Ell.	2.	260	1.	17
Lubeck Ell.	1.	903		
Nurembourg Foot.	1.	006	0.	94
Nurembourg Ell.	2.	227		
Bavaria Foot.	0.	954		
ienna Foot.	1.	053	0.	83
Spain *and* Portugal.				
Spaniſh Palm, or Palm of *Caſtile*.	0.	751	0.	99
Spaniſh Vare, or Rod, 4 Palms.	3.	004		
Spaniſh Foot, $\frac{1}{3}$ of the Vare.	1.	001		
Liſbon Vare.	2.	750	1.	06
Gibralter Vare.	2.	760	1.	03
Toledo Foot.	0.	899	1.	00
Toledo Vare.	2.	685		
Italy.				
Roman Foot on the Monument of *Cullatius*.	0.	967	1.	23
Roman Foot on the Monument of *Statilius*.	0.	972		
Roman Palm for Building, whereof 10 make a Cauna.	0.	732		
Bononia Foot.	1.	204	1.	27
Bononia Perch, (whereof 500 make a Mile.)	12.	040		

Places Names.	Feet	1000 Parts	Pounds	10 Part
Florence Brace or Ell.	1.	913	1.	23
Naples Palm.	2.	100	1.	43
Naples Cauna.	6.	880		
Genoa Palm.	0.	830	1.	42
Mantua Foot.	1.	569	1.	43
Milan Calamus.	6.	544	1.	40
Parma Cubit.	1.	866	1.	43
Venice Foot.	1.	162	1.	53
Other Places.				
Dantzick Foot.	0.	944	1.	19
Dantzick Ell.	1.	903		
Copenhagen Foot.	0.	965	0.	94
Prague Foot.	1.	026	1.	06
Turin Foot.	1.	062		
Riga Foot.	1.	831		
China Cubit.	1.	016		
Cairo Cubit.	1.	824	1.	61
Perſian Araſh.	3.	197		
Turkiſh Pike (at *Conſtantinople*) the Greater.	2.	200	0.	8
The *Greek* Foot.	1.	007		

2. *A T*

2. *A TABLE, comparing Foreign Meaſures with the* Engliſh, *By* HENRY PHILIPS.

Places Names.	Ells	10000 Parts
London Ell.	1.	0000
Amſterdam Ell.	0.	5900
Antwerp Ell.	0.	6000
Arras Ell.	0.	6060
Bridges Ell.	0.	6097
Nuremberg Ell.	0.	5747
Colen Ell.	0.	4807
Liſle Ell	0.	6024
Maſtricht Ell.	0.	6369
Frankford Ell.	0.	4792
Dantzick Ell.	0.	7228
Vienna Ell.	0.	6896
Paris Aulne.	1.	0526
Roven Aulne.	0.	9708
Lyons Aulne.	0.	9836
Callais Aulne.	0.	6369
Venice Linnen Brace.	0.	5555
Venice Silk Brace.	0.	5102
Lucques Brace.	0.	5000
Florence Brace.	0.	4901
Millan Brace.	0.	4347
Leghorn Brace.	0.	5000
Iſles of *Madera* Brace.	0.	9681
Sevil Vare.	0.	7407
Lisbon Vare.	1.	0000
Caſtile Vare.	0.	7207
Andaluſia Vare.	0.	7339
Granado Vare.	0.	7339
Genoa Palm.	0.	2079
Saragoſſa Cane.	1.	1881
Rome Cane.	1.	7857
Barſelona Cane.	1.	4035
Valentia Cane.	0.	8247

3. *A TABLE, comparing Foreign Weights with the* Engliſh. *By* HENRY PHILIPS.

Places Names.	Pounds	10000 Parts
London Pound Averd.	1.	0000
Antwerp Pound.	0.	9615
Amſterdam Pound.	0.	9000
Abbeville Pound.	0.	9100
Ancona Pound.	1.	2820
Avignon Pound.	1.	1200
Burdeaux Pound.	0.	9100
Burgoine Pound.	0.	9100
Bolognia Pound.	1.	2500
Bridges Pound.	0.	9800
Callabria Pound.	1.	3698
Callais Pound.	1.	0700
Conſtantinople Pound.	0.	8474
Diep Pound.	0.	9100
Dantzick Pound.	1.	1600
Ferrara Pound.	1.	3333
Florence Pound.	1.	2880
Flanders (all) Pound.	1.	0600
Geneva Pound.	0.	9345
Genoa Pound Subtle.	1.	4084
Groſs.	1.	4285
Hamburg Pound.	0.	9200
Holland Pound.	0.	9500
Luxborne Pound.	0.	8810
Lyons Pound Common.	1.	0700
Silk Weight.	0.	9800
Cuſtomers Weight.	0.	9000
Leghorn Pound.	1.	3333
Millan Pound.	1.	4285
Mirandola Pound.	1.	3333

Norim-

Places Names.		Pounds	10000 Parts
Norimberg Pound.		0.	8800
Naples pound.		1.	4084
Paris pound.		0.	8900
Prague pound.		0.	8300
Placentia pound.		1.	3888
Rochel pound.		1.	1200
Rome pound.		1.	2700
Rovan pound	Vicont.	0.	8750
	Common Weight.	0.	9017
Sevil pound.		1.	0800
Thoulouſa pound.		1.	1200
Turin pound.		1.	2195
Venice pound	Subtle.	1.	5625
	Groſs.	0.	9433
Vienna pound.		0.	8130

The Uſe of the foregoing Tables is very eaſy. Thus. Say, As 1, is to the Number in the $\left\{\begin{matrix}\text{2d}\\\text{3d}\end{matrix}\right\}$ Column (of the firſt Table) againſt the given Place; ſo is the given Number of $\left\{\begin{matrix}\text{Meaſures}\\\text{Weights}\end{matrix}\right\}$ to the Number of *Engliſh* $\left\{\begin{matrix}\text{Feet}\\\text{Pounds Averd.}\end{matrix}\right\}$ equivalent thereto.

Example 1.

Let it be requir'd to reduce 100 *Paris Royal Feet* into *Engliſh*. To do which I ſay, As 1 : 1.068 : : 100 : 106.8 the Anſwer ſought.

Example 2.

Let it be requir'd to reduce 100 Pound at *Paris* into *Engliſh* Pounds. Here I ſay, As 1 : 0,93 : : 100 : 93. the Anſwer.

So, by theſe two Examples it appears, That 100 *Paris* Royal Feet are equal to 106.8 Feet *Engliſh*; And 100 *Paris* Pounds are equal to 93 Pounds Averd. *Engliſh.* By the ſame Method you may reduce any other Foreign Weight or Meaſure into *Engliſh.* The thing is too plain to need another Example.

To reduce *Engliſh* Feet or Pounds into Foreign, is but the Converſe of the former; and therefore to do it, this is

The RULE.

Say, As the Number in the $\left\{\begin{matrix}\text{2d}\\ \text{3d}\end{matrix}\right\}$ Column (of the firſt Table) againſt the given Place, is to 1; ſo is the Number of *Engliſh* $\left\{\begin{matrix}\text{Feet}\\ \text{Pounds Averd.}\end{matrix}\right\}$ to the Number of Foreign $\left\{\begin{matrix}\text{Meaſures}\\ \text{Pounds}\end{matrix}\right\}$ equivalent thereto.

Example 1.

In 1068 *Engliſh* Feet, how many *Paris* Royal Feet? Anſwer, 1000. For, as 1.068 : 1 : : 1068 : 1000.

Example 2.

In 93 Pound Averd. *Engliſh*, how many Pound at *Paris*? Anſwer, 100. For, As 0.93 : 1 : : 93 : 100.

The Uſe of the ſecond and third Table is the very ſame as the firſt; only the ſecond Table reduces Foreign Meaſures into Ells, and not into Feet.

CHAP. V.

Progreſſion by the Line.

PRogreſſion is of two Kinds, Arithmetical and Geometrieal.

An Arithmetical Progreſſion is made by the continual Addition of any certain Number (as ſuppoſe, 1, or 2, or 3, *&c.*) to any given Number. Thus, 1, 2, 3, 4. and 2, 4, 6, 8, *&c.* 2, 5, 8, 11, *&c.* are Arithmetical Progreſſions.

A Geometrical Progreſſion is made by the continual Multiplication (of any given Number) by any certain Number; as ſuppoſe by 2, or 3, or 4, *&c.* Thus, 2, 4, 8, 16, *&c.* 1, 3, 9, 27, *&c.* are Geometrical Progreſſions.

The Number by which any Progreſſion is made, *i. e.* the Number continually added to the given Number, in an Arithmetical Progreſſion, is call'd *the Exceſs*; or the Number by which the given Number is continually multiply'd, in a Geometrical Progreſſion, is call'd the *Ratio.* This being premis'd, I come to ſhew how in [illegible]

PROP. I.

To find the laſt Number or Term of any Arithmetical Progreſſion.

The ANALOGY.

As 1, is to a Number leſs by 1 than the Number of the Places in the given Progreſſion; ſo is the Exceſs, to a fourth; to which fourth, add the firſt Number (or Term,) and their Sum is the laſt Number or Term ſought.

Example.

What is the laſt Term of a Progreſſion of ſix Places, whoſe firſt Term is 1, and Exceſs 9? Anſwer, 46. For, as 1 : 5 :: 9 : 45. To which, adding the firſt Term, it makes 46.

PROP. II.

To find the Total Sum of any Arithmetical Progreſſion.

The ANALOGY.

As 1, is to the Sum of the firſt and laſt Terms of the given Progreſſion; ſo is half the Number of Places, to the Total Sum of the Progreſſion, ſought.

Or thus:

As 1, is to half the Sum of the firſt and laſt Terms; ſo is the Number of Places, to the Total Sum of the Progreſſion, ſought.

PROP. III.

To find the laſt Term or Number of any Geometrical Progreſſion.

The RULE.

Extend the Compaſſes from 1, to the Exceſs; and with that Extent, ſet one Foot of the Compaſſes in the firſt Term, and turn them forward once leſs than the Number of Terms, and they will reſt on the laſt Term, ſought.

Example.

What is the laſt Term of the Geometrical Progreſſion, whoſe firſt Term is 1, *Ratio* 2, and Number of Terms 6? Anſwer, 32. For (according to the Rule) the Extent from 1, to 2, (the Exceſs) will reach at 5 times turning, from 1 (the firſt Term) to 32, the laſt Term, ſought.

PROP. IV.

To find the Total Sum of any Geometrical Progreſſion.

The RULE.

As the *Ratio* leſs by 1, is to the laſt Term leſs by the firſt Term; ſo is the *Ratio* to a fourth. To which fourth,

fourth add the firſt Term, the Sum is the Total Sum of the Progreſſion.

Example.

What is the Total Sum of a Geometrical Progreſſion, whoſe firſt Term is 2, Ratio 3, and laſt Term 54? Anſwer, 80. For, as 2, (the Ratio leſs by 1), is to 52, (the laſt Term leſs by the firſt); ſo is 3 (the Ratio), to 78: (the fourth) to which adding 2 (the firſt Term) it makes 80, the Total Sum of the Progreſſion, ſought.

I might have added ſeveral other Propoſitions in Progreſſion; but (thoſe already exhibited being the moſt uſeful, and the others containing more of Curioſity than Uſe,) I have purpoſely omitted them.

CHAP. VI.

The Golden Rule Direct, by the Line.

(1.) THis Rule may well be call'd the *Golden Rule*, it being the moſt Excellent and Uſeful Rule of all the Rules in Arithmetick.

(2.) This Rule teaches the Reſolution of any Analogy or Proportion; that is, it ſhews how, by having three Numbers given, to find a fourth that ſhall bear the ſame proportion to the third, that the ſecond doth to the firſt. Now

(3.) For Working this Rule by the Line, this is

The RULE.

Say, As the firſt given Term, is to the ſecond; ſo is the third, to the fourth, ſought.

Or thus.

As the firſt given Term, is to the third; ſo is the ſecond, to the fourth, ſought.

Wehre-

Wherefore,

Always extend the Compaſſes from the firſt given Term or Number, to the ſecond; and that Extent of the Compaſſes, apply'd the ſame way, upon the Line, ſhall reach from the third given Term or Number, to the fourth, requir'd.

Otherwiſe,

Extend the Compaſſes from the firſt Term, to the third; and that Extent, apply'd the ſame way, ſhall reach from the ſecond, to the fourth, requir'd.

(5.) Either of theſe ways will effect the ſame thing: And 'tis neceſſary thus to vary the Method ſometimes, to avoid opening the Compaſſes too wide; for when they are open'd to a very large Extent, you can neither take off any Diſtance ſo exactly, nor give ſo good an Eſtimate of any Parts requir'd, as you may do when they are open'd to a leſſer Diſtance.

But all the Difficulty in this Rule, conſiſts in the right Ordering of the Terms (or Numbers) in any Queſtion propounded: For ſame Queſtions are naturally ſo intricate, or elſe they are ſo intricately ſtated, that 'tis no eaſy matter to know which is the firſt, ſecond, or third Term. And therefore, that the Reader may not be at a loſs in this Point, I ſhall here lay down this Plain and General

RULE,

(6.) To place the Terms right in any Queſtion of the Golden Rule.

In all Queſtions of the Golden Rule, there be three Terms propounded, *viz.* two of Suppoſition, and one of Demand; and that of Demand is always the third Term; and the Term of Suppoſition, of the ſame Denomination with the Term of Demand, muſt be the firſt Term; and the other Term of Suppoſition, the ſecond Term.

(7.) When the Terms (in any Queſtion in the Golden Rule) have been rank'd in their due Order, by the foregoing Rule; then the Queſtion is to be ſolv'd by the fourth Rule of this Chapter.

(8.) If the Compaſſes be too ſhort (as many times
ey are) to reach from the firſt Term, to the ſecond;
r from the firſt, to the third; then you muſt take ſe-
ral Denominations of Number upon the ſame Radius
f the Line; (*e. g.* from Units to Tens, or Hundreds, *&c.*)
d obſerve to give a right Denomination to the fourth
erm. But, becauſe in ſuch a Caſe the Learner may
at a loſs to know what Denomination (whether
nits, or Tens, or Hundreds, *&c.*) to give to the
urth Term; I ſhall here lay down

A General RULE,

(9.) To work the Golden Rule, when the Compaſſes are too ſhort to reach from the firſt Term, to the ſecond or third.

In this Caſe, you muſt take the ſecond or third Term
pon the ſame Radius (of the Line) with the firſt Term.
g. If the Queſtion were, If 2 give 30, what ſhall 50
ve? Here the Diſtance from 2 (in the firſt Radius)
30, or 50 (in the ſecond Radius) is too great for
oſt ordinary Compaſſes; Wherefore, I extend the
ompaſſes from 2 to 3 (in the ſame Radius) account-
g 3 for 30; and that Extent apply'd the ſame way
om 50, (in the other Radius) reaches to 75. But
ow, to know what Denomination to give to this 75,
bſerve this

General RULE,

(10.) To know how many Figures there ſhould be in the fourth Term of any Proportion.

Firſt find (by Note 2d in Multiplication) how many
igures would be in the Product of the ſecond and third
erms, which account as the Number of Figures in a
ividend; and then reckon the firſt Term for a Diviſor,
d find (by Note 2d in Diviſion) how many Figures
ould be in the Quotient; for ſo many there will be
the fourth Term.

So, in the laſt Example, in the Product of 30 and
0 (the ſecond and third Terms) there will be found

(by Note 2d in Multiplication) 4 places of Figures; which being accounted for the Number of Figures in Dividend, and reckoning 2 (the firſt Term) for a Diviſor; there will be found (by Note 2d in Diviſion) t be 3 places of Figures in the Quotient; and ſo many there will be in the fourth Term. Therefore, that 75 found to be the fourth, muſt be accounted 750. Thi is very plain and eaſy; but 'tis alſo very tedious: Therefore

(11.) In this Caſe of the Compaſſes being too ſhor I uſe to work thus:

I take the ſecond or third Term upon the ſame Radius (of the Line) that I take the firſt Term on, (according to the Ninth Rule of this Chapter) and call by the ſame Denomination with the firſt Term; (whether it be Units, or Tens, or Hundreds, &c.) But th will be better illuſtrated by an Example: Wherefore take that Example in the Ninth Rule; *viz.* If 2, gi 30; what ſhall 50 give? Here I take 30, at 3, the ſame Radius with 2, (the firſt Term) and call by the ſame Denomination with the firſt Term, *viz.* Units. Then I reaſon thus; If 2 give 3, 50 will gi 75, (by the third and fourth Rule of this Chapter Then I reaſon again, thus: But my ſecond Term is 3 which is 1 Denomination higher than I ſuppos'd i (for 30, is Tens; and 3, which I took for 30, is b Units;) and therefore my fourth Term muſt be 1 Denomination higher than I found it by the former Suppoſition; (*i. e.* it muſt be Hundreds.) Therefore t fourth Term will be 750. Which is the Anſwer to th Queſtion.

This way is quicker than the former; and there is difficulty in it, if you do but obſerve to denominate yo fourth Term ſo many Denominations higher or low than you found it by your ſuppoſitious Analogy, your ſecond Term is higher or lower than you had ſuppos'd it.

(12.) I would have the Learner often practice (ſo as

e very perfect in) the Golden Rule ; for he'll find that
oſt of the Rules in this Book, are laid down Analogical-
; and ſo to be ſolv'd by this Rule.

(13.) Therefore, this Rule being of ſuch excellent Uſe
all Parts of the Mathematicks, (as will appear from
e following Pages of this Book,) I ſhall need *here*,
ly to propoſe a few Queſtions, whereby to ſhew its
xcellency in reſolving Queſtions purely Arithmeti-
l.

Qu. 1. If 100 *l.* yield 4 *l.* Intereſt for a Year ; what
all 75 *l.* yield? Anſwer, 3 *l.* For, as 100 : 4 : : 75 : 3.

Qu. 2. If one Acre of Land be worth 15 *s.* a year,
hat is 40 Acres (of the like Land) worth by the
ear? Anſwer, 600 *s.* which (by Prop. 2. in Reducti-
n) makes 30 *l.*

Qu. 3. Cloth at 5 *s.* the Yard ; what comes 36 Yards
? Anſwer, 180 *s.* equal to 9 *l.* For, as 1 : 5 : : 36 : 180.
, as 1 : .25 *l.* : : 36 : 9 *l.*

Qu. 4. Nails at 5 *d.* the Hundred ; how many for
d.? Anſwer, 60. For, as 5 *d.* 100 : : 3 *d.* : 60.

Qu. 5. If a Servant have 5 *l.* a Year ; what is that a
ay? Anſwer, 3.29 *d.* For, as 365 (the Days in a
ear) : 1200 (the Pence in 5 *l.*) : 1 (Day) : 3.29 *d.*
mething better than 3 *d.* 1 *f.*

Qu. 6. If 108 *l.* in 12 Months, gain 6 *l.* Intereſt ;
uch will it gain in 7 Months? Anſwer, 3 *l.* 10 *s.*
nſwer, 3 *l.* 10 *s.* For, as 12 : 6 : : 7 : 3.5 *l.* equal to
l. 10 *s.*

Almoſt an infinite Variety of Examples might be ad-
ed ; but for Brevity ſake, let theſe ſerve as a taſte of
e reſt.

(14.) The Effects of the Golden Rule Direct, are

1. Its firſt and general Effect, is to find a fourth Pro-
rtional, conſiſting of two equal Reaſons. The Rule
r this is laid down before, in the third and fourth
ules of this Chapter.

2. The ſecond Effect is, by the Price or Value of any
e thing, to find the Price or Value of many things, of

the like Kind and Goodneſs; by ſaying, As one thing, is to its Price; ſo is any Number of Things, to their Price.

3. The third Effect is, by the Price or Value of many things, to find the Price of one; by ſaying, As any Number of Things, is to their Price; ſo is one, to its Price.

4. The fourth Effect is, by the Price of any Number of Things, to find the Price of any other Number of Things, of the like kind; by ſaying, As any Number of Things, is to their Price; ſo is any other Number of Things, to their Price.

5. The fifth Effect is, the reducing of Moneys, Weights, or Meaſures, from one Denomination to another. The Rules for which are already taught in the Chapter of Reduction.

So let this ſuffice for the Golden Rule Direct.

CHAP. VII.

The Golden Rule Reverſe, by the Line.

(1.) THE Golden Rule Reverſe, is that by which, from three Numbers given, we find a fourth in a reciprocal Proportion, inverted to the Proportion given.

(2.) For Working of this Rule, this is the

ANALOGY.

As the third Term, is to the $\left\{\begin{matrix}\text{1ſt,}\\\text{2d,}\end{matrix}\right\}$ ſo is the $\left\{\begin{matrix}\text{2d}\\\text{1ſt}\end{matrix}\right\}$ to the fourth.

Wherefore,

Always extend the Compaſſes from the firſt Term, to the $\left\{\begin{matrix}\text{1ſt,}\\\text{2d,}\end{matrix}\right\}$ the ſame Extent ſhall reach (being apply'd the ſame way) from the $\left\{\begin{matrix}\text{2d,}\\\text{1ſt,}\end{matrix}\right\}$ to the 4th.

Or, Extend the Compaſſes from the firſt Term to the hird, the ſame Extent (being apply'd the contrary way) hall reach from the ſecond Term, to the fourth.

(4.) This Rule being but of ſmall Uſe in other Parts f the Mathematicks, I ſhall here exemplify its Uſeful- eſs in Arithmetick.

Qu. 1. If 8 Men do a Piece of Work in 12 Days, in ow many Days will 16 Men do the ſame? Anſw. In Days.

Qu. 2. If 8 Men do a Piece of Work in 12 Days, how any Men muſt there be to do the ſame in 6 Days? nſw. 16. This Queſtion may prove the foregoing.

Qu. 3. If (according to the Standard, Statute, or aw of *England*) the Penny-Loaf
{ White,
Wheaten,
Houſhold, }
muſt eigh, when Wheat is at Five Shillings the Buſhel,
{ 7 oz. 7 d.w.
11. oz.
1 lb. 2 oz. 14 d.w. }
Troy, or
{ 8 oz.
12 oz.
16 oz. or 1 lb. }
verd. How much muſt the Penny-Loaf (White, Vheaten, or Houſhold,) weigh, when Wheat is at .6*d.* the Buſhel? Anſ. The Penny-Loaf
{ White,
Wheaten,
Houſhold, }
uſt Weigh by Troy-Weight
{ 1 lb. 2 oz.
1 lb. 10 oz.
2 lb. 5 oz. 8 d.w. }
and y Averd. Weight
{ 1 lb.
1 lb. 8 oz.
2 lb. }

Qu. 4. How many Pieces of Money or Merchandiſe, alu'd at 20 *s.* *per* Piece, are to be given or receiv'd r 240 Pieces, valu'd at 12 *s.* *per* Piece? Anſ. 144. or, As 12 *s* : 240 Pieces : : 20 *s* : 144 Pieces.

Qu. 5. How many Yards of Canvas that is Ell wide, ill ſuffice to Line 20 Yards of Say that is three Quar- ers (of a Yard) wide? Anſ. 12 Yards. For 3 : 20 : : : 12 reciprocally.

Qu. 6. How many Foot of Matting, of 2 Foot wide, will cover a Floor 20 Foot wide, and 24 Foot long? Anſ. 240 Foot. For, As 20 : 24 : : 2 : 240.

Qu. 7. If (according to the Statute) a Right-Angl'd Paralelogram of 40 Perches in length, and 4 in breadth, make an Acre of Land; how much in length muſt there be, when the breadth is 16 Perches? Anſ. 10 Perches. For, As 4 : 40 : : 16 : 10.

Qu. 8. If 12 Inches in breadth, and 12 in length, make a Superficial Foot; how much muſt there go in length to make a Foot, when the breadth is but 3 Inches? Anſ. 48 Inches. For, As 12 : 12 : : 3 : 48.

Qu. 9. I lent my Friend 600 *l.* for 8 Months; how much muſt he lend me again for 12 Months, to recompence my Curteſy? Anſ. 400 *l.* For, As 8 M : 600 *l.* : : 12 M : 400 *l.*

Qu. 10. I lent my Friend 600 *l.* for 8 Months; for how long time muſt he lend me 400 *l.* to recompence my Curteſy? Anſ. For 12 Months. For, As 600 *l.* 8 M. 400 *l.* 12 Months.

Qu. 11. If for 24 *s.* I have 1200 lb. Weight carry'd 36 Miles; how many Miles ſhall 1800 lb. Weight be carry'd for the ſame Money? Anſ. 24 Miles. For, As 1200 : 36 : : 1800 : 24.

Qu. 12. If for 24 *s.* I have 1200 *l.* Weight carry'd 36 Miles; how many Pound Weight ſhall I have carry'd 24 Miles for the ſame Money? Anſ. 1800 lb. Weight. For, As 36 : 1200 : : 24 : 1800.

Qu. 13. A Colonel is beſieg'd in a Town, in which are 1200 Souldiers, with Proviſion for 3 Months; how many of his Souldiers muſt he diſmiſs, that his Victuals may laſt the reſt of his Men 8 Months? Anſ. He muſt keep 450 Men, and diſmiſs the reſt. For, As 3 : 1200 : : 8 : 450.

Qu. 14. If a Field will graze 21 Horſes, for 6 Weeks; how many will he graze for 7 Week? Anſ. 18. For, As 6 : 21 : : 7 : 18.

Qu. 15. If a Field will graze 21 Horſes, for 6 Weeks; for or how long will it graze 11 Horſes? Anſ. For 7 Weeks. or, As 21 : 6 : : 18 : 7.

Qu. 16. How many Groats are equivalent to 24 Sixpences? Anſ. 36. For, As 6 *d.* 24 : : 4 *d.* 36.

Qu. 17. At 5 *d.* a piece; what comes 48 Things to? Anſ. 20 *s.* For, As 5 *d* : 48 : : 12 *d* (equal to 1 *s.*) : 20 (12d's or) Shillings.

Qu. 18. Things at 5 *d.* a piece; how many ſhall I uy for 20 *s.*? Anſ. 48. For, As 12 *d* : 20 (12 d's) : : *d* : 48 (5d's).

I forbear to mention any more Examples in this Rule, hoſe being ſufficient to ſhew the Excellency thereof: ut the Ingenious Reader may propoſe an almoſt Infinity (if I may ſo ſpeak) of other uſeful Queſtions, which ay be ſolv'd by this Rule.

(5.) The Effects of the Golden Rule Reverſe, are

1. The firſt and general Effect of the Golden Rule Reverſe, is contain'd in the Definition of the ſame; that , to find a fourth Term, in a reciprocal Proportion, inverted to the Proportion given. The Rule for this is id down before, in the ſecond and third Rule of this Chapter.

2. The ſecond Effect is, by the Prizes, or Values of wo ſeveral Pieces of Money, or Merchandiſe; To find ow many pieces of one Price, are equivalent to a given Number of the other. And conſequently, to $\left\{\begin{array}{l}\text{reduce}\\\text{exchange}\end{array}\right\}$ ne ſort of $\left\{\begin{array}{l}\text{Money into}\\\text{Merchandiſe for}\end{array}\right\}$ another. This is exmplify'd in Qu. 4. 16, 17, and 18.

3. The third Effect is, by two differing Prizes of Wheat, and the Weight of a Loaf of Bread, made anwerable to one of the Prizes; To find the Weight of he ſame Loaf, made anſwerable to the other Price; *Et è contra.* This is exemplify'd in Qu. 3.

4. The fourth Effect is, by having the length and readth of one Paralelogram, and the length or breadth f another; To find the breadth or length of the other,

that the later Paralelogram may be equal to the former, this has been exemplify'd in Qu. 5, 6, 7, and 8.

5. The fifth Effect is, by a Double Time, and a Capital Sum of Money borrow'd or lent; To find out another Capital Sum anſwerable to one of the given Times. Or otherwiſe, by two Capital Sums, and a Time anſwerable to one of 'em; To find a Time anſwerable to the other Capital Sum. This was exemplify'd in Qu. 9, and 10.

6. The ſixth Effect is, by two differing Weights of Carriage, and the Diſtance one of 'em is carried, for a certain Price; To find the Diſtance the other Weight muſt be carry'd, for the ſame Price. Or otherwiſe. By two Diſtances, and a Weight carry'd one of the Diſtances for a certain Price; To find what Weight muſt be carry'd the other Diſtance, for the ſame Price. This was exemplify'd Qu. 11, and 12.

7. The ſeventh Effect is, by a double Number of Workmen, and the Time that one of them is doing a piece of Work; To find how long the other Number of Workmen will be doing the ſame piece of Work. Or otherwiſe. By a double Time, wherein a piece of Work was done, and the Number of Workmen doing it in one of thoſe Times; To find the Number of Men to do it in the other Time. This was exemplify'd in Qu. 1, and 2.

The eighth Effect is, by a double price of Proviſion, and the Number of Creatures nouriſh'd for a certain time, with a certain quantity of it, bought at one of the prizes: To find how many of the ſame kind of Creatures, may be nouriſh'd, for the ſame time, with the ſame Value of Proviſions, bought at the other price.

The ninth Effect is, by a certain quantity of Proviſions, and the Number of Creatures it will nouriſh for a certain time: To find how many it will nouriſh for another certain time. Or otherwiſe. By a certain quantity of Proviſions, and the Number of Creatures it will nouriſh for a certain time, to find how long the ſame quantity of Proviſions will nouriſh another Number of the ſame kind of Creatures. This was exemplify'd in Qu. 15, and 16.

Many more are the *Effects* of this Rule, which any one may eaſily diſcover; and therefore I purpoſely pretermit 'em.

(6.) To know when a Queſtion is to be reſolv'd by the Direct, and when by the Reverſe Rule.

The RULE.

Place the Terms in their due Order, (by Rule 6. of Chap. 6.) and then if Reaſon ſhew, that the $\left\{\begin{matrix}\text{greater,}\\ \text{leſſer,}\end{matrix}\right\}$ the third Term is, the $\left\{\begin{matrix}\text{greater,}\\ \text{leſſer,}\end{matrix}\right\}$ the 4th Term muſt be; then the Queſtion is in the Direct Rule: But if Reaſon ſhew, that the $\left\{\begin{matrix}\text{greater,}\\ \text{leſſer,}\end{matrix}\right\}$ the third Term is, the $\left\{\begin{matrix}\text{leſſer,}\\ \text{greater,}\end{matrix}\right\}$ the fourth Term muſt be; then the Queſtion is in the Reverſe Rule.

(7.) To work the Golden Rule without reſpect to Direct or Reverſe.

The RULE.

Firſt place the Terms in their due Order, by Rule 6. of Chap. 6. And then, if Reaſon ſhow, that the fourth Term ſought ought to be $\left\{\begin{matrix}\text{greater}\\ \text{leſſer}\end{matrix}\right\}$ than the Term of Demand; Then ſay, As the $\left\{\begin{matrix}\text{leſſer}\\ \text{greater}\end{matrix}\right\}$ Term of Suppoſition, is to the $\left\{\begin{matrix}\text{greater,}\\ \text{leſſer,}\end{matrix}\right\}$ ſo is the Term of Demand, to the fourth Term ſought.

CHAP.

CHAP. VIII.

The Double Rule of Three, or Golden Rule compos'd of Five Numbers, by the Line.

(1.) THis Rule has its Name, from its having Five Numbers given, to find a ſixth in proportion thereunto: And is reſolv'd by two ſingle Rules of Three. But, before you can work this Rule, you muſt know how

(2.) To diſpoſe the given Terms (or Numbers) in a due Order and Place, preparative for Reſolution.

The RULE.

In all Queſtions in this Rule, there are five Terms propounded; *viz.* Three Terms of Suppoſition, and two of Demand. Of the three Terms of Suppoſition, let that which has the ſame Denomination with the Term requir'd, be placed in the ſecond place, and place the other two Terms of Suppoſition one above another in the firſt place; and then place the two Terms of Demand one above another in the third place. Only obſerve to place Numbers of like Denomination in the ſame Rank; as two in the upper, and two in the lower Rank. Then

(3.) To Reſolve any Queſtion in the Double Rule of Three, or Golden Rule compos'd; this is

The RULE.

Having plac'd the given Terms (or Numbers) in their due Order, (by the ſecond Rule of this Chapter;) then ſay, As the firſt Term in the upper Rank, is to the ſecond; ſo is the third in the ſame Rank, to a fourth. Again, As the firſt Term in the lower Rank, is to the fourth laſt found; ſo is the other Term in the lower Rank, to the Term requir'd.

Note. Before you work the two Analogies, you muſt be ſure to find (by Rule 6. of Chap. 7.) whether they are to be wrought by the Direct or Reverſe Rule; and accordingly work them.

(4.) Some Queſtions exemplifying the Uſefulneſs of this Rule.

Qu. 1. If 100 *l.* Principal, in 12 Months, gain 6 *l.* Intereſt; What will 75 *l.* Principal, gain in 9 Months? Anſ. 3 *l.* 7 *s.* 6 *d.*

For the Terms being placed in Order by the ſecond Rule, will ſtand thus; $\left\{\begin{matrix}100\,l : 6\,l :: 75\,l.\\ 12\,M: \qquad 9\,M:\end{matrix}\right\}$ Then I ſay, As 00 *l* : 6 *l* :: 75 *l* : 4.5 *l* (equal to 4 *l.* 10 *s.*) Again, As 12 M : 4.5 *l* : : 9 M : 3.375 *l* equal to 3 *l.* 7 *s.* 6 *d.*

Qu. 2. If 100 *l.* Principal, in 12 Months, gain 6 *l.* In how long time will 75 *l.* gain 3 *l.* 7 *s.* 6 *d.*? Anſ. in 9 Months.

Qu. 3. If 100 *l.* Principal, in 12 Months, gain 6 *l.* What Principal will gain 3 *l.* 7 *s.* 6 *s.* in 9 Months? Anſ. 75 *l.* Theſe three Queſtions mutually prove one another.

Qu. 4. If the Carriage of 100 lb. 30 Miles, coſt 12 *d.* What will the Carriage of 500 lb. coſt, being carried 100 Miles? Anſ. 200 *d.* equal to 16 *s.* 8 *d.*

Qu. $\left\{\begin{matrix}5.\\6.\\7.\end{matrix}\right\}$ If a Regiment of 936 Souldiers, eat 351 Quarters of Wheat, in 168 Days; How many Quarters will ſuffice 11232 Souldiers for 56 Days? Or, how many Souldiers will 1404 Quarters ſuffice for 56 Days? Or, how many Days will 1404 Quarters ſuffice 11232 Souldiers? Anſ. To the firſt, 1404 Quarters. To the ſecond, 11232 Souldiers. And to the third, 56 Days.

Qu. $\left\{\begin{matrix}8.\\9.\\10.\end{matrix}\right\}$ If 8 Men, in 7 Days, Mow 40 Acres; How many Acres will 24 Men mow in 28 Days? Or, in how many Days will 480 Acres be mow'd by 24 Men? Or, how many Men muſt there be to mow 480 Acres in 28 Days? Anſ. To the firſt, 480 Acres. To the ſecond, 28 Days. And to the third, 24 Men.

Qu. 11. If 40 *s.* is the Wages of 8 Men, for 5 Days; What ſhall be the Wages of 32 Men, for 24 Days? Anſ. 768 *s.* equal to 38 *l.* 8 *s.*

Qu. 12. If 14 Horſes eat 56 Buſhels of Provender, in 16 Days; How many Buſhels will 20 Horſes eat in 24 Days? Anſ. 120 Buſhels.

Qu. 13. If 8 Cannons, in one Day, ſpend 48 Barrels of Powder; How many Barrels will 24 Cannons ſpend in 12 Days? Anſ 1728 Barrels.

Qu. 14. If in a Family, conſiſting of 7 Perſons, there are drunk out 36 Gallons of Beer in 12 Days; How many Gallons will there be drunk out in 8 Days, by another Family, conſiſting of 14 Perſons? Anſ. 48 Gallons.

Qu. 15. If, when the Buſhel of Wheat coſts 3 *s.* 4 *d.* the Penny-Loaf weighs 12 Ounces; What ſhall a Loaf worth 9 *d.* weigh, when Wheat is at 10 *s.* the Buſhel? Anſ. 36 Ounces.

Qu. 16. A Man put out 75 *l.* to receive Intereſt for the ſame, and when it had continu'd 9 Months, he receiv'd (for Principal and Intereſt) 78 *l.* 7 *s.* 6 *d.* Now, at what rate *per Cent. per Annum*, did he receive Intereſt? Anſ. at 6 *l. per Cent. per Annum.*

Qu. 17. If a Captain ſet 300 Pioneers to work, and they, in 8 Hours, caſt a Trench of 200 Rods; How many Pioneers will be able, with a like Trench, in 3 Hours, to intrench a Camp 3400 Rods? Anſ. 13600 Pioneers.

CHAP. IX.

The Rule of Fellowſhip, by the Line.

(1.) THE Rule of Fellowſhip is when two (or more) Men trade together, with one Common Stock; and when they have gain'd, or loſt, it ſhews how to find each Man's particular Gain, or Loſs.

(2.) The Rule of Fellowſhip is of two Kinds; *viz.* ither *without Time*, or *with Time*.

(3.) For Fellowſhip without Time, this is

The RULE.

As the whole Stock, is to the whole $\left\{\begin{array}{l}\text{Gain;}\\ \text{Loſs;}\end{array}\right\}$ ſo is ch Man's particular Stock, to his particular $\left\{\begin{array}{l}\text{Gain.}\\ \text{Loſs.}\end{array}\right.$

Example.

Four Merchants, **A. B. C. D.** trading together, made Common Stock of Money, to the Value of 240 *l.* Whereof **A.** put into the Stock 30 *l.* B. 50 *l.* C. 60 *l.* nd D. 100 *l.* This Stock they occupy'd till it was creas'd to 3000 *l.* Now, What ſhould each Man reive at the parting of the Money? Anſ. A. muſt reeive 375 *l.* B. 625 *l.* C. 750 *l.* and D. 1250 *l.* For, s to 240, is to 3000; ſo is 30 *l.* to 375 *l.* and ſo is 0 *l.* to 625 *l.* and ſo is 60 *l.* to 750 *l.* and ſo is 100 *l.* 1250 *l.*

(4.) The ſame Rule ſerveth in a Caſe of Bankrupt; y ſaying,

As the whole Sum of the Bankrupt's Debts, is to the whole Value of his Goods; ſo is each Man's particular Debt, to his Share of the Goods; that each Man may ear his proportionable Part in the Loſs.

Example.

If the Bankrupt's Goods be valu'd at 500 *l.* and he e in debt 1000 *l.* to 4 Men, A. B. C. D. of which 100 *l.* due to A. 200 *l.* to B. 300 *l.* to C. and 400 *l.* to D. Now, what ought to be each Man's *Quota* or Share of he Goods? Anſ. A. muſt have 50 *l.* B. 100 *l.* C. 50 *l.* and D. 200 *l.* So that you ſee, in this Example, each Man loſeth ½ his Debt.

(5.) A Caſe of Bankrupt may alſo be ſolved by this

RULE.

As the whole Sum of the Bankrupt's Debts, is to its

Exceſs above the whole Value of his Goods, (whic Exceſs is the whole Loſs that all his Creditors muſt ſu ſtain;) ſo is each Man's particular Debt, to the Lo that he muſt ſuſtain. This needs no Example.

(6.) Fellowſhip with Time, is wrought by this

RULE.

Multiply each Man's particular Stock by his Time then ſay, As the Sum of theſe Products, is to th whole $\left\{\begin{array}{l}\text{Gain;}\\ \text{Loſs;}\end{array}\right\}$ ſo is each Man's particular Produ to his particular $\left\{\begin{array}{l}\text{Gain.}\\ \text{Loſs.}\end{array}\right.$

Example.

Four Merchants, A. B. C. D. made a Common Stoc which at the Year's end was increas'd to 35145 *l.* O this Stock, A. laid in 669 *l.* which he took again a 10 Months end; B. laid in 810 *l.* for 8 Months; C laid in 900 *l.* for 7 Months; and D. laid in 1040 *l* for 12 Months. Now, what is each Man's Portion o the Gains? Anſ. A. muſt have 7359 *l.* B. 7128 *l.* C 6930 *l.* and D. 13728 *l.*

CHAP. X.

The Rules of Practice, by the Line.

(1.) THE Rules of Practice is but a Compendiu of the Golden Rule Direct, when the fi Term is one. Its Uſe is

(2.) By knowing the Price of one thing, to find th Price of any Number of things at that Rate.

The RULE.

Say, As one thing, is to its Price (reduc'd to its lea Denomination;) ſo is any Number of Things, to th Price.

Examp

Example.

Cloth at 2 *s.* 2 *d.* the Yard; What comes 1000 ards to? Anſ. 108 *l.* 6 *s.* 8 *d.* For, As 1 : 26 *d.* :: 00 : 2600 *d.* equal to 108 *l.* 6 *s.* 8 *d.*

CHAP. XI.

he Extraction of the ſquare Root, by the Line.

THE Square Root of a Number is a Number which being multiply'd by it ſelf, produceth the ven Number: Or, the Square Root of a Number ay be defin'd, to be, a mean Proportional between e given Number and Unity. To find it, this is

The RULE.

Divide (with your Compaſſes) the Space (on the ne) between 1 and the given Number into 2 equal arts; and that middle Point where the Compaſſes reſt, ews the Square Root ſought.

Example.

Let it be requir'd to extract the Square Root of 36. o do which, I divide the Diſtance (on the Line) between 36, and 1, into 2 equal Parts, and the Compaſſes ſt upon 6. Which is the Square Root ſought.

And thus the Square Root of 81, will be found to be ; of 144, 12; of 256, 16; and ſo of other Numrs, as in this TABLE.

Root	Square	Root	Square	Root	Square
1	1	8	64	15	225
2	4	9	81	16	256
3	9	10	100	17	289
4	16	11	121	18	324
5	25	12	144	19	361
6	36	13	169	20	400
7	49	14	196	21	441

Note 1. If the Number of Figures (in the given Number) be odd; it will be beſt to place Unity, at 1 in the middle of the Line; for ſo the Root and Square will both fall forwards towards 10 at the end of the Line. But

Note 2. If the Number of Figures be even, it will then be beſt to place your Unity, at 10 at the end of the Line; and ſo the Root and Square will both fall backwards, towards the middle of the Line.

Note 3. Half the Number of Figures (in the given Number) if even; or the greater half, if odd, is equal to the Number of Figures in the Square Root.

CHAP. XII.

The Extraction of the Cube-Root, by the Line.

THE Cube Root of a Number, is a Number, which being multiply'd twice into it ſelf, produceth the given Number. Thus the Cube-Root of 64 is 4: For 4 multiply'd by 4 is 16; and that (again) multiply'd by 4, produceth 64.

Or, The Cube-Root of a Number, may be defin'd, to be, the firſt of 2 mean Proportionals, between the given Number and Unity. To find it, this is

The RULE.

Divide (with your Compaſſes) the Space (on the Line) between 1 and the given Number, into 3 equal Parts; and where the firſt Part from 1, endeth, that Point (of the Line) exhibiteth the Cube-Root ſought.

Example.

What is the Cube-Root of 216? Anſ. 6. For the Space between 1, and 216, being divided into 3 equal Parts, the Compaſſes will firſt reſt on 6, the Root ſought.

And thus the Cube-Root of 729, will be found to 9; of 1728, 12; and ſo of other Numbers, as this

TABLE.

Root	Cube	Root	Cube	Root	Cube
1	1	8	512	15	3375
2	8	9	729	16	4096
3	27	10	1000	17	4913
4	64	11	1331	18	5832
5	125	12	1728	19	6859
6	216	13	2197	20	8000
7	343	14	2744	21	9261

Note 1. If you add 2 to the Number of Figures in e given Number, and divide that Sum by 3, the Quo- nt will ſhew the Number of Figures in the Root.

Note 2. If (working according to the firſt Note) ere do nothing remain; it will be beſt to place Unity *the* 1 in the middle of the Line; and ſo the Root, e Square, and the Cube, will fall forwards towards , at the End.

But if 1 remain; then Unity may be placed at either d, *viz.* at 1 at the Beginning, or at 10 at the End; d ſo the Cube will be 1 Radius from the Unity, ei- er forward, or backward.

But if 2 remain; then 10 at the End of the Line, uſt be Unity; and the Root, the Square, and the ube, will always be in the ſame Radius of the Line; at is, between 10 at the End, and 1 in the Middle.

CHAP. XIII.

Intereſt and Annuities, by the Line.

(1.) WHen one Man lends Money to another for a time, upon condition, that he pay him ſo much *per Cent.* for the Uſe of it; ſuch Money paid for the Uſe of it, is call'd the *Uſe, Loan,* or *Intereſt*; and the Money lent is call'd the Principal; and ſo much as is allow'd for the Uſe of 100 *l.* for a Year, is call'd the Rate. If at the Year's end, the Principal be not paid, and the Intereſt do not become a part of the Principal; then it is call'd Simple Intereſt: but if at each Year's end, the Intereſt become a part of the Principal; then it is call'd Compound Intereſt.

(2.) To find the Simple Intereſt of any Sum of Money, at any Rate, for any given Time.

The RULE.

As 100 *l.* is to the Rate; ſo is the Principal, to its Intereſt for one Year. Then for any other time ſay,

$$\text{As}\left\{\begin{array}{l}1,\\12,\\365\frac{1}{4},\text{ or}\\365.25,\end{array}\right\}\text{is to the given Time, in}\left\{\begin{array}{l}\text{Years;}\\\text{Months;}\\\text{Days;}\end{array}\right\}$$

ſo is the Intereſt for one Year, to its Intereſt for the given Time, in Years, Months, or Days.

Otherwiſe,

(3.) If you would have the Anſwer exhibit the Amount or Agregate of the Principal and Intereſt; then ſay,

As 100 *l.* is to 100 *l.* added to the Rate; ſo is the Principal, to the Amount of the Principal and Rate for one Year. Then for any other Time ſay,

$$\text{As}\left\{\begin{array}{l}1,\\12,\\365\frac{1}{4},\text{ or}\\365.25,\end{array}\right\}\text{is to the given Time, in}\left\{\begin{array}{l}\text{Years;}\\\text{Months;}\\\text{Days;}\end{array}\right.$$

o is the Amount for one Year, to the Amount for the iven Time, in Years, Months, or Days.

Example.

What is the Intereſt of 1000 *l.* for five Years, at 5 *l.* *er Cent. per Annum*? Anſ. 250 *l.* (by the ſecond Rule f this Chapter.) Which added to the Principal, gives 1250 *l.* for the whole Amount; the ſame that would ave been found by this third Rule. So that you ſee, f 1000 *l.* be put out to Uſe for five Years, at the Rate f 5 *l. per Cent. per Annum*, it will be increas'd to 1250 *l.*

(4.) Rebate or Diſcount is when Money is due at the nd of a certain Time; and the Debtor agrees with his Creditor, to pay him Ready-Money, if he will allow im ſo much (as they agree for) *per Cent. per Annum*, (in conſideration of his receiving his Money before it s due.) I ſay, this Allowance is call'd Rebate or Diſount; and the Creditor muſt receive ſo much Ready-Money, as being put out to Uſe, (at the Rate of Diſount agreed on, and till the Time it was due,) it may mount to the juſt Sum that would be then due. Now,

(5.) To find the preſent Worth of any Sum of Mo-ey, due at the End of any Time to come, allowing Diſcount or Rebate at any Rate (propos'd) Simple Intereſt; this is

The RULE.

Firſt find (by Rule 2d of this Chapter) the Intereſt f 100 *l.* at the Rate, and for the Time, the Rebate s to be allow'd: then ſay,

As 100 *l.* added to its Intereſt (now found), is to 100 *l.* ſo is the given Sum to its preſent Worth.

Or otherwiſe.

Firſt find (by Rule 3d) the Amount of 100 *l.* at the Rate, and for the Time, the Rebate is to be allow'd: then ſay,

As the Increaſe or Amount of 100 *l.* (now found), is o 100 *l.* ſo is the given Sum, to its preſent Worth.

Exam-

Example.

What preſent Money will ſatisfy a Debt of 240 *l.* due at the End of 4 Years yet to come, Diſcount or Rebate being allow'd, at the Rate of 5 *l.* *per Cent. per Annum*? Anſ. 200 *l.*

(6.) To find the Increaſe or Amount of any Annuity, or Yearly Rent or Income, in any Time; allowing Simple Intereſt (at any Rate *per Cent. per Annum*) for each Yearly Payment, from the Time it firſt became due.

The RULE.

Find (by Rule 2d) the Intereſt (for one Year, and at the Rate propos'd) of one Year's Payment; and multiply it by the given Number of Years, and multiply that Product by $\frac{1}{2}$ the Number of Years leſſen'd by 1, (or multiply $\frac{1}{2}$ that Product by the Number of Years leſſen'd by 1.) this laſt Product is the Sum of the Intereſt of the Annuities; which added to the Sum of the Annuities, is equal to the total Amount or Increaſe of the Annuities.

Example.

There is an Annuity or Yearly Rent, or Income of 200 *l. per Annum*, forborn to the End of 6 Years; Now, how much is due at the End of the ſaid Time, allowing Simple Intereſt, at the Rate of 6 *l. per Cent. per Annum*? Anſ. 1380 *l.* For the Sum of the Annuities is 1200 *l.* and the Sum of the Intereſt is 180 *l.* there being no Intereſt allow'd (in this Caſe) for the laſt Annuity, (or Year's Rent) that being paid as ſoon as it becomes due.

(7.) To find the preſent Worth of an Annuity or Yearly Rent, allowing Diſcount or Rebate, (at any Rate *per Cent. per Annum*) Simple Intereſt.

The RULE.

Find (by Rule 6. the Increaſe or Amount of the propoſed Annuity, for the propoſed Time, and at the propoſed Rate. Then (by Rule 5.) find the preſent Worth of this Sum (thus found) due at the End of the propoſed Time; and that ſhall be the preſent Worth of he Annuity.

Example.

There is a Leaſe of a Houſe or Land, worth 12 *l.* *er Annum*, and there is 16 Years of the Leaſe yet to ome; which Leaſe a Man would buy, if he could lay ut his Money ſo as to gain 10 *l.* *per Cent.* The Queſtion is, What is this Leaſe worth? Anſ. 129$\frac{3}{13}$ *l.*

(8.) Compound Intereſt, or Intereſt upon Intereſt. Vhat it is, has been ſhew'd above, in Number 1 of his Chapter. Now,

To find what any Sum of Money will be increas'd to, being put out to Intereſt) in any Number of Years, nd at any Rate *per Cent.* reckoning Compound Intereſt, r Intereſt upon Intereſt; this is

The RULE.

Extend the Compaſſes from 100 *l.* to the Increaſe of 00 *l.* in one Year; that Extent of the Compaſſes being turn'd (from the Sum propos'd) the ſame way, as many times as there be Years propos'd, ſhall at laſt ay at the Sum of the Principal and Intereſt requir'd.

Example.

What ſhall 143 *l.* 10 *s.* amount to in 10 Years, at he Rate of 6 *l.* *per Cent.* Compound Intereſt? Anſ. 257 *l.* ferè.

(9.) To find the preſent Worth of any Sum of Money, due at any Time to come, allowing Diſcount or Rebate, at any Rate *per Cent.* Compound Intereſt.

The RULE.

Extend the Compaſſes from the Increaſe of 100 *l.* in ne Year, to 100 *l.* that Extent of the Compaſſes being urn'd (from the Sum propos'd) the ſame way, as many times as there be Years propos'd, ſhall at laſt ay at the preſent Worth ſought.

Exam-

Example.

What is the preſent Worth of 257 *l.* due at the End of 10 Years, allowing Diſcount or Rebate at 6 *l. per Cent.* Compound Intereſt? Anſ. 143 *l.* 10 *s.*

(10.) To find the Increaſe or Amount of an Annuity or Yearly Rent, in any Number of Years, allowing Compound Intereſt, at any Rate *per Cent.*

The RULE.

Firſt find what Principal will (at the propos'd Rate) in one Year, gain the Annual Rent propos'd; thus

Say, As the propos'd Rate *per Cent.* is to 100 *l.* ſo is the propos'd Yearly Rent, to his Principal, ſought.

Then find (by Rule 8.) what Sum that Principal will be increas'd to, in the propos'd Number of Years, and at the propos'd Rate; and from that Sum ſubſtract the Principal, and the Remainder is the Increaſe of the Annuity ſought.

Example.

Suppoſe a Landlord live far from his Tenant, and yet judging his Tenant honeſt, and able to pay him; is content to forbear his Rent 14 Years, upon condition his Tenant will allow him 6 *l. per Cent. per Annum* (Compound Intereſt) for the Forbearance; and ſuppoſe the Rent be 33 *l. per Annum.* Now the Queſtion is, What muſt the Landlord receive at the End of the 14 Years? Anſ. 693 *l.* 10 *s.*

(11.) To find the preſent Worth of an Annuity or Yearly Rent, allowing Diſcount or Rebate, at any Rate *per Cent.* Compound Intereſt.

The RULE.

Firſt find (by Rule 10.) the Increaſe or Amount of the propos'd Annuity, for the propos'd Time, and at the propos'd Rate.

Then find (by Rule 9.) the preſent Worth, of the Sum thus found due at the End of the propos'd Time; and that ſhall be the preſent Worth of the Annuity ſought.

Example.

What is a Leaſe of 25 *l. per Annum*, to continue for 21 Years, worth in preſent Money, Diſcount or Reate (at 6 *l. per Cent.* Compound Intereſt) being alow'd to the Purchaſer? Anſ. 294 *l.* 1 *s.* 6 *d.* 1 *q.*

There are ſeveral other Caſes in Intereſt, but theſe eing the moſt Uſeful ones; I ſhall (to avoid Volunoſity) wave the reſt in this place.

CHAP. XIV.

ilitary Affairs or Stratarithmetry, by the Line.

PROP. I.

o find the Number of Men contain'd in any Square or or Oblong Battalia.

The RULE.

AS 1, is to the Number of Men in Rank; ſo is the Number of Men in File, to the Number of Men the Battalia requir'd. This needs no Example.

PROP. II.

Any Number of Souldiers being propos'd; To Order them into a Square Battalia; that is, there ſhall be as many in Rank as in File.

The RULE.

Extract the Square Root of the Given Number of ouldiers, (by Chap. 11.) and that ſhall be the Numer of Men in Rank and File requir'd.

Example.

Suppoſe it were requir'd to Order 1600 Men into a quare Battalia; How many Men muſt there be in Rank nd File? Anſ. 40 in each.

PROP.

PROP. III.

Any Number of Souldiers being propos'd; To Order them into a Double (or Triple, or Quadruple, or, &c.) Battalia; that is, having twice (or three times, or four times, or, &c.) as many in Rank as in File.

The RULE.

Extract the Square Root of ½ (or ⅓, or ¼, or, *&c.*) the given Number of Men; and that is the Number of Men in File; and Double (or Triple, or Quadruple, or, *&c.*) that Number is the Number in Rank.

Example.

Suppoſe 1800 Men were to be placed in Battalia, ſo as the Number of Men in Rank, might be double to the Number in File; How many muſt there be in Rank, and how many in File? Anſ. 30 in File, and 60 in Rank.

PROP. VI.

Any Number of Souldiers being propos'd to be put in Battalia, and a certain Number aſſign'd to be put in $\left\{\begin{matrix}\textit{Rank;}\\\textit{File;}\end{matrix}\right\}$

To find the Number in $\left\{\begin{matrix}\textit{File.}\\\textit{Rank.}\end{matrix}\right.$

The RULE.

As the Number of Men aſſign'd to be put in $\left\{\begin{matrix}\text{Rank,}\\\text{File,}\end{matrix}\right\}$ is to the whole Number of Souldiers; ſo is 1, to the Number to be put in $\left\{\begin{matrix}\text{Rank.}\\\text{File.}\end{matrix}\right.$

Example.

Let it be requir'd to place 872 Men in Battalia, ſo that there ſhall be 8 in File; How many muſt there be in Rank? Anſ. 109. For, As 8 : 872 : : 1 : 109.

PROP.

PROP. V.

Any Number of Souldiers being propos'd; To place them in Battalia, ſo that the Number of Men in $\left\{\begin{array}{l}\textit{Rank,}\\ \textit{File,}\end{array}\right\}$ *ſhall be to the Number of Men in* $\left\{\begin{array}{l}\textit{File,}\\ \textit{Rank,}\end{array}\right\}$ *according to any Proportion aſſign'd.*

The RULE.

As the Ratio reſpecting the $\left\{\begin{array}{l}\text{Rank,}\\ \text{File,}\end{array}\right\}$ is to the Ra- reſpecting the $\left\{\begin{array}{l}\text{File;}\\ \text{Rank;}\end{array}\right\}$ ſo is the whole Number Souldiers, to a 4th. Whoſe Square Root is the Num- r of Men in $\left\{\begin{array}{l}\text{File.}\\ \text{Rank.}\end{array}\right.$

Having thus found the Number of Men to be pla- d in $\left\{\begin{array}{l}\text{File;}\\ \text{Rank;}\end{array}\right\}$ Find the Number to be placed in $\begin{array}{l}\text{Rank}\\ \text{File}\end{array}\Big\}$ by Prop. IV.

Example.

Let it be requir'd to place 600 Men in Battalia, ſo at the Number of Men in Rank, may be to the Num- r in File, as 3 to 2. Now, how many muſt there in Rank, and how many in File? Anſ. 20 in File, d 30 in Rank.

PROP. VI.

Any Number of Souldiers being given to be put in Battalia, and their Number and Diſtance in Rank and File, being given alſo; To find how much Ground they will occupy.

The RULE.

As 1, is to the Diſtance in $\left\{\begin{array}{l}\text{Rank;}\\ \text{File;}\end{array}\right\}$ ſo is the Number in $\left\{\begin{array}{l}\text{Rank, leſs by 1,}\\ \text{File, leſs by 1,}\end{array}\right\}$ to a 4th. Then the Rect angle or Product of theſe 4ths, gives the quantity o Ground ſought, in ſuch Meaſures as the Diſtance i Rank and File were given in.

Example.

Let it be requir'd to place 600 Men in Battalia, ſ as there may be 30 in Rank, and 20 in File; and th all to ſtand at *Order*; (i. e. 3 Foot diſtant in Rank, an as much in File;) Now, how much Ground will th occupy? Anſ. 4959 Square Feet: It being an Ob long piece of Ground, of 87 Feet long, and 57 Fe broad. For, As 1 : 3 : : ſo is $\left\{\begin{array}{l}29 :\\ 19 :\end{array}\right\}$ to $\left\{\begin{array}{l}87.\\ 57.\end{array}\right\}$ Th 87 multiply'd by 57, produceth 4959.

PROP. VII.

The Hight of the Wall of a Fort or Caſtle being giv with the breadth of the Trench about the Wall; To fi the Length of a Scaling-Ladder, that will reach fr the Edge of the Trench to the Top of the Wall.

The R U L E.

Square the Hight of the Wall, and alſo the Bread of the Trench; add theſe two Numbers together, a extract the Square Root of their Sum; and ſo ſhall y have the Length of the Scaling-Ladder requir'd.

Example.

Let the Hight of the Wall of a Fort be 16 Feet, a the Breadth of the Trench about it 12 Feet; How lo muſt the Scaling-Ladder be? Anſ. 20 Foot. For Square of 16, is 256; and the Square of 12, is 1 their Sum is 400. Whoſe Square Root is 20.

CHA

CHAP. XV.

Duplicate Proportion, by the Line.

DUplicate Proportion is ſuch a Proportion as is between Lines and Superficies, or between Superfi- s and Lines.

(1.) For the Proportion of *Lines* or *Superficies*; is is the

RULE.

As the Firſt Term, is to the Second of the ſame De- mination; ſo is the Third, at twice turning the Com- ſſes, to the Fourth required. Which Rule is thus to underſtood. Extend the Compaſſes, from the firſt ven Number, to the ſecond of the ſame Denomina- on; that Extent being turn'd twice (either the ſame, the contrary way, as Reaſon will direct,) from the ird Number, will reach to the fourth required.

Example 1.

If the Diameter of a Circle be 14 Inches, and the ea thereof be 154 Inches; What is the Area of ano- er Circle, whoſe Diameter is 28 Inches? Anſ. 616 ches. For the Extent from 14 to 28, being turn'd twice e ſame way) from 154, will reach to 616.

Example 2.

If a Piece of Land that is 20 Perches Square, be worth 0*l.* How much is a Piece of Land (of the ſame good- ſs) worth, that is 30 Perches Square? Anſ. 67.5 *l.* at is, 67 *l.* 10 *s.*

Example 3.

If a Fathom of Rope of 6 Inches Compaſs, weigh lb. How much ſhall a Fathom of Rope of 12 Inches ompaſs weigh? Anſ. 24 lb.

Example 4.

How many Acres of Land of our *Engliſh* Meaſure o 16.5 Foot to the Perch, are equal to 30 *Iriſh* Acres o 21 Foot to the Perch? Anſ. 48.6 Acres.

Note. That in Duplicate Proportion, there are alway three Terms or Numbers given, to find a 4th; and o thoſe three given Numbers, two are always of the ſam Denomination; and of thoſe two, one is always a Term of Suppoſition, (which muſt be the firſt Term,) and the other of Demand, which muſt be the ſecond Term; and the remaining given Term muſt be the third Term.

Then, if Reaſon ſhew that the $\left\{\begin{matrix}\text{greater}\\ \text{leſſer}\end{matrix}\right\}$ the ſecon Term *is*, the $\left\{\begin{matrix}\text{greater}\\ \text{leſſer}\end{matrix}\right\}$ the 4th Term muſt be; the the Extent of the Compaſſes from the firſt to the ſe cond, muſt be turn'd *the ſame way*, from the third to wards the fourth.

But, if Reaſon ſhew, that the $\left\{\begin{matrix}\text{greater}\\ \text{leſſer}\end{matrix}\right\}$ the ſecon Term is, the $\left\{\begin{matrix}\text{leſſer}\\ \text{greater}\end{matrix}\right\}$ the fourth Term muſt be then the Extent from the firſt to the ſecond, muſt b turn'd *the contrary way*, from the third towards th fourth.

So that you ſee, ſome Queſtions are in Duplicat Proportion Direct, (as were the three firſt Examples; and ſome in Duplicate Proportion Reverſe, (as in th fourth Example.)

(2.) For the Proportion of Superficies to Lines; thi is the

RULE.

Extend the Compaſſes to half the Diſtance betwee the two given Numbers of the ſame Denomination and that Extent (being apply'd the right way, acordin to the Note at the end of the firſt Rule of this Chapter; ſhall reach from the other given Number, to the fourt requir'd.

Example 1.

Let there be two Circles given, the Area of one of hem being 154 Inches, and its Diameter 14 Inches; nd the Area of the other Circle 616 Inches; What its Diameter? Anſ. 28 Inches. For the Diſtance beween 154, and 616, being divided into two equal arts, that Extent of the Compaſſes will reach from 4 to 28.

Example 2.

There is a Piece of Land of 20 Perches ſquare, orth 30 *l.* There is another Piece of Land (of the me Goodneſs) worth 67 *l.* 10 *s.* How many Perches uare ought that Piece to be? Anſ. 30.

Example 3.

If a Fathom of Rope of 6 Inches Compaſs, weigh lb. How much will the Compaſs of that Rope be, of hich a Fathom weighs 24 lb.? Anſ. 12 Inches.

Example 4.

If a Piece of Land contain 30 Acres, being meaſur'd the *Iriſh* Pole of 21 Foot; How long muſt the Pole Perch be, by which the ſame Piece of Land being eaſur'd, it will contain 48.6 Acres? Anſ. It muſt be 6.5 Foot: which is the *Engliſh* Pole or Perch.

(3.) There is another way of working Duplicate roportion; which tho it be more tedious by the Line, et, becauſe it expreſſes ſomething of the Nature of the ule, I ſhall here exhibit it.

The RULE.

Having found (by the Note at the End of the firſt ule) which is the firſt and ſecond Term: Then, for

$$\text{e Proportion of}\left\{\begin{array}{l}\text{Lines to Superficies}\\ \text{Superficies to Lines}\end{array}\right\}\text{ſay, As the}$$

$$\left.\begin{array}{l}\text{Square of the firſt, is to the Square of the ſecond;}\\ \text{Square Root of the firſt, is to the Sq. Root of the 2d;}\end{array}\right\}$$

is the third, to the fourth, ſought.

(4.) The Effects of Duplicate Proportion are many; I ſhall here only hint at ſome of them.

1. The firſt and general Effect of Duplicate Proportion is, By having three Numbers given; To find a fourth in a Duplicate Proportion: that is, that the third Number given, may be to the fourth ſought; Either, (1.) As the Square of the firſt, is to the Square of the ſecond (of the ſame Denomination:) Or, (2.) As the Square Root of the firſt, is to the Square Root of the ſecond.

The firſt of theſe is properly call'd *Duplicate Proportion*; and the Rule for it, is laid down in Rule 1. of this Chapter. But the ſecond, tho it (be comprehended under, and) be alſo commonly call'd *Duplicate Proportion*; yet is it more properly call'd Subduplicate Proportion: The Rule to work it, is laid down in the ſecond Rule of this Chapter.

2. The ſecond Effect is, By having the Diameter of a Circle (or the Side of any regular Polygon) given, with its Area; and the Diameter of another Circle (or the Side of another regular Polygon of the ſame kind) alſo given, to find its Area. This was Exemplify'd in *Rule* 1. *Example* 2.

The third Effect is, By having the Diameter of any one Circle (or the Side of any one regular Polygon) given, with its Value or Worth; and the Diameter of another Circle (or the Side of another regular Polygon of the ſame kind) alſo given, to find its Value or Worth. This was Exemplify'd in *Rule* 1. *Example* 2.

4. The fourth Effect is, By having the Diameter or Circumference of any one Cylinder (or the Side or Circumference of any one regular Polygonal Priſm) given with its Gravity or Weight; and the Diameter or Circumference of another Cylinder (or the Side or Circumference of another Priſm of the ſame kind) of the ſame length, alſo given; To find its Gravity or Weight. This was Exemplify'd in *Rule* 1. *Example* 3.

5. Th

5. The fifth Effect is, By having the Weight and Value of one Diamond (or other Precious Stone) given; and the Weight of another Diamond (or other Precious Stone) being alſo given; To find its Value, This has not been Exemplify'd; but it may be wrought ither by *Rule* 1, or according to *Rule* 3, by this

ANALOGY.

As the Square of the Weight of one Diamond (or other Precious Stone) is to the Square of the Weight of nother; ſo is the Value of the firſt, to the Value of he laſt.

Note. A good Diamond weighing 1 Carat, (*i. e.* Grains,) is valu'd at 150 *French* Livers. But if the Diamond be not perfect, then they allow but 80 Livers o a Carat. Therefore,

(5.) To find the Value of any Diamond, this is he

RULE.

As 1, is to the Square of the Weight (in Carats) of any Diamond; ſo is $\left\{\begin{matrix}150\\80\end{matrix}\right\}$ *French* Livers, (for $\left\{\begin{matrix}\text{a good one,}\\\text{an imperfect one,}\end{matrix}\right\}$ to the Value (in *French* Livers) of the given Diamond.

Note. A *French* Liver is about 1 *s.* 6 *d. Engliſh.*

There are many more Effects of Duplicate Proportion, which for Brevity ſake I omit. The Reader may eaſily deduce 4 others from the Examples of the ſecond Rule, he 3 firſt being juſt contrary to the ſecond, third, and fourth Effect.

CHAP. XVI.

Triplicate Proportion, by the Line.

TRiplicate Proportion is ſuch a Proportion as is between *Lines* and *Solids*, or between *Solids* and *Lines*. Thus 'tis commonly taken; tho more properly, the former would be call'd Triplicate, and the later Subtriplicate Proportion.

(1.) For the Proportion of Lines to Solids, this is

The RULE.

As the firſt given Number, is to the ſecond of the ſame Denomination; ſo is the third (at three times turning the Compaſſes), to the fourth requir'd.

Therefore,

Always extend the Compaſſes from the firſt given Number, to the ſecond, of the ſame Denomination; that Extent of the Compaſſes, being turn'd three times the right way, (according to the Nature of the Queſtion, which Reaſon will direct,) from the third Number, will reach to the fourth requir'd.

Example 1.

If a Bullet, whoſe Diameter is 4 Inches, weigh 9 lb. What will another Bullet of the ſame Metal weigh, whoſe Diameter is 8 Inches? Anſ. 72 lb. For the Extent of the Compaſſes from 4, (the Diameter of the Bullet whoſe Weight is given,) to 8, (the Diameter of the Bullet whoſe Weight is ſought; will reach (being three times turn'd the ſame way) from 9, (the Weight of the Bullet known,) to 72, the Weight of the Bullet ſought.

Example 2.

If the Diameter of a Globe be 1 Inch, and the Solidity thereof be .5238 of an Inch; What is the Solidity of another Globe, whoſe Diameter is 10 Inches? Anſ. 523.8 Inches; that is, almoſt 524 Inches.

Example 3.

If a Globe of Silver of 1 Inch Diameter, be worth 4.4 *s.* (for ſo it will be at 5 *s.* the Ounce;) What will nother Globe of Silver be worth, whoſe Diameter is Inches? Anſ. 921,6 *s.* that is, 46 *l.* 1 *s.* 7⅕ *d.*

Example 4.

If a Saker of 3.75 Inches Diameter in the Bore, require 4 lb. of Powder for its due Charge; What will Demi-canon of 6.5 Inches Diameter in the Bore, require for its Charge? Anſ. 20.8 lb. *feré.*

Example 5.

If a Braſs Saker, whoſe Diameter is 11.5 Inches, do veigh 1000 lb. What will another Piece of Ordnance of the ſame Metal and Shape) weigh, whoſe Diame- er is 8.75 Inches? Anſ. 837 lb.

Example 6.

If a Ship, whoſe Burden is 300 Tun, be 75 Feet in he Keel; What ſhall be the Burden of another Ship of the ſame Mold) whoſe Keel is 100 Feet? Anſ. 713 Tun.

(2.) For the Proportion of Solids to Lines, this is

The RULE.

Extend the Compaſſes to one third of the Diſtance etween the two given Numbers of the ſame Denomiation; and that Extent of the Compaſſes being apply'd he right way, (which Reaſon will direct,) will reach om the other given Number, to the fourth requir'd.

Example 1.

If a Bullet, whoſe Diameter is 4 Inches, weigh 9 lb. hat is the Diameter of another Bullet, (of the ſame etal) whoſe Weight is 72 lb.? Anſ. 8 Inches. For the iſtance between 9 and 72, being divided into three qual Parts; that Extent of the Compaſſes, will reach rom 4 to 8.

Exam-

Example 2.

If the Diameter of a Globe be 1 Inch, and the Solidity thereof be .5238 of an Inch; What is the Diameter of another Globe, whoſe Solidity is 523.8 Inches? Anſ. 10 Inches.

Example 3.

If a Globe of Silver, of 1 Inch Diameter, be worth 14.4 *s.* What will be the Diameter of another Globe of Silver, that is worth 921.6 *s.*? Anſ. 4 Inches.

Example 4.

If a Saker of 3.75 Inches Diameter in the Bore, require 4 lb. of Powder for its due Charge; What will be the Diameter (in the Bore) of a Demi-Canon, that requires 20.8 lb. of Powder for its Charge? Anſ. 6.5 Inches.

Example 5.

If a Braſs Saker, whoſe Diameter is 11.5 Inches, do weigh 1800 lb. What will be the Diameter of another Piece of Ordnance, (of the ſame Metal and Shape) whoſe Weight is 837 lb.? Anſ. 8.75 Inches.

Example 6.

If a Ship, whoſe Burden is 300 Tun, be 75 Feet in the Keel; What ſhall be the Length of the Keel of another Ship, (of the ſame Mold) whoſe Burden is 713 Tun? Anſ. 100 Feet.

(3.) There is another way of working Triplicate Proportion; which, tho it be more tedious by the Line, yet, becauſe it gives ſome Light to the Nature of the Rule, I ſhall here exhibit it.

The RULE.

Firſt find (by the Note in *Rule* 1. of the preceding Chapter,) which is the firſt and ſecond Term. Then, for the Proportion of $\left\{\begin{array}{l}\text{Lines to Solids,}\\ \text{Solids to Lines,}\end{array}\right\}$ ſay, As the $\left\{\begin{array}{l}\text{Cube of the firſt, to the Cube of the ſecond;}\\ \text{Cube-Root of the 1ſt, to the Cube-Root of the 2d;}\end{array}\right\}$ ſo is the 3d, to the 4th ſought.

(4.) The **Effects of Triplicate Proportion**, are

1. The firſt and general Effect is, By having three Numbers given; To find a fourth in a Triplicate Proportion; that is, that the third Number given, may be to the fourth ſought; Either, (1.) As the Cube of the firſt, is to the Cube of the ſecond; Or (2.) As the Cube-Root of the firſt, is to the Cube-Root of the ſecond. The Rule for the $\left\{\begin{array}{l}\text{firſt}\\\text{ſecond}\end{array}\right\}$ is laid down in the $\left\{\begin{array}{l}\text{firſt}\\\text{ſecond}\end{array}\right\}$ Rule of this Chapter. Or, either of them may be wrought by the third Rule.

$\left.\begin{array}{l}2.\\3.\\4.\end{array}\right\}$ The $\left\{\begin{array}{l}\text{2d}\\\text{3d}\\\text{4th}\end{array}\right\}$ Effect is, By having the Diameter of any one Globe (or, the Side of any one of the Platonick Bodies) given, with its $\left\{\begin{array}{l}\text{Gravity or Weight;}\\\text{Solidity;}\\\text{Value or Worth;}\end{array}\right\}$ and the Diameter of another Globe (or the Side of another Platonick Body, of the ſame kind) alſo given; To find its $\left\{\begin{array}{l}\text{Gravity.}\\\text{Solidity.}\\\text{Value.}\end{array}\right\}$ This was Exemplify'd in Example the $\left\{\begin{array}{l}\text{firſt}\\\text{ſecond}\\\text{third}\end{array}\right\}$ of the firſt Rule of this Chapter.

5. The fifth Effect is, By knowing the Quantity (or Weight) of Powder, that will load one Piece of Ordnance, the Diameter of whoſe Bore is given; To find the Quantity (or Weight) of (the ſame ſort of) Powder, that will load another Piece of Ordnance, the Diameter of whoſe Bore is alſo given. This was Exemplify'd in *Rule* 1. *Examp.* 4.

6 The ſixth Effect is, By knowing the Diameter and Weight of any one Piece of Ordnance; To find the Weight of another Piece of Ordnance, (of the

ſame Metal and Shape) whoſe Diameter is alſo given. This was Exemplify'd in *Rule* 1. *Example* 5.

7. The ſeventh Effect is, By knowing the Length of the Keel, Breadth at the Beam, or Depth in the Hold, of any one Ship, with its Burthen; To find the Burthen of another Ship, (of the ſame Mold) whoſe Length in the Keel, Breadth in the Beam, or Depth in the Hold, is alſo given. This was Exemplify'd in *Rule* 1. *Example* 6.

Many are the Effects of Triplicate Proportion; but for Brevity I omit the reſt. The Reader may eaſily (*per ſe*) deduce ſix other Effects, from the ſix Examples of the ſecond Rule of this Chapter; they being exactly contrary to the ſecond, third, fourth, fifth, ſixth, and ſeventh Effects already mention'd.

So much ſhall ſuffice (at this time) for the Uſe of the Line of Numbers in Arithmetick. I ſhall now proceed (*Deo juvante*) to treat in

---

BOOK

BOOK II.

f the Vſe of the Line of Numbers in Geometry.

PROEME.

I Am not here to teach the whole Art of Geometry, (for that would take up a far larger Volume alone, than this is deſign'd to be;) but only to w how the moſt uſual, and moſt uſeful Propoſitions, y be perform'd by the Line of Numbers.

2. I ſhall therefore ſuppoſe the Reader to be well n in all the Definitions of Lines, Superficies, and ids.

3. Having already (in Book 1. Chap. 6.) laid down les ſufficient for the Reſolution of any Analogy; I ll, in all the following Pages of this Book, lay down Rules Analogically; or in ſuch Tables as are eaſily ucible to Analogies.

4. I ſhall here conſider Geometry, as it may (proly) be diſtinguiſh'd into theſe four General Heads, Parts; *viz.*

1 The Menſuration of Lines.
2 The Menſuration of Superficies.
3 The Menſuration of Solids.
4 The Menſuration of Concaves.

. Under the firſt Head, I ſhall conſider, (1.) The portion between the Diameters (or Circumferences) Circles, and the Sides of Regular Polygons; and that er in reſpect of Equality, or of their being inſcribed in, or circumſcribed about one another. (2.) The Proportion between the Diameters of Spheres, and th Sides of the Platonic Bodies; and that either in reſpect to their Equality, or their Inſcription in, or Ci cumſcription about one another. And (3.) The takin of Hights and Diſtances.

6. Under the ſecond Head, I ſhall conſider, (1.) Th Menſuration of Superficial Figures. (2.) The Menſ ration of the Superficiality of Solid Bodies. And (3 The Application of Superficial Meaſure to the Menſur tion of Artificer's Work.

7. Under the third Head, I ſhall conſider, (1.) T Menſuration of Solid Bodies; Whether they are Irreg lar, ſimply Regular, or the Platonick Bodies. (2.) T Application of Solid Meaſure to the Menſuration of A tificer's Work. And (3.) Staticks; or the Art of fin ing the Gravity of any Body. It is here done on by its Dimenſions: A thing (to my knowledge) ne treated of by any.

8. Under the fourth Head I ſhall conſider the A of Gauging.

CHAP. I.

The Menſuration of Lines, by the Line Numbers.

PROP. I.

To find the Circumference of a Circle, the Diameter ing given.

The RULE.

As	7 to 22;	ſo is the Diameter	*Archimed*
	1 to 3.14159;	to the Circumference,	*Van Culen*
	113 to 355;	according to	*Metius.*

Which laſt Analogy is accounted the moſt exact; there be little difference betwixt any of them.

P R O

PROP. II.

find the Circumference of a Circle, the Area being given.

The RULE.

As 7 to 88; ſo is the Area, to the Square of the Cir- nference. Therefore, the Analogy being wrought, raſt the ſquare Root of the 4th Term, (by Book I. p. XI.) and that Root is the thing ſought.

PROP. III.

find the Diameter of a Circle, the Circumference being given.

The RULE.

22 to 7;	ſo is the Circumference, to the Diameter, according to	*Archimedes.*
3.14159 to 1;		*Van Culen.*
355 to 113;		*Metius.*

PROP. IV.

find the Diameter of a Circle; the Area being given.

The RULE.

As 11 to 14; ſo is the Area, to the Square of the Dia- ter. Therefore, the Analogy being wrought, Extract Square Root of the 4th Term, (by Book I. Chap. XI.) that Root is the thing ſought.

These four Propoſitions are ſo very plain and eaſy, t they need no Examples.

PROP. V.

he Diameter of a Circle being given; To find the Side of any regular Polygon (from the Trigon to the Decagon) that may be either inſcribed in, or circumſcribed about, or is equal to, the given Circle,

Here are 24 Propoſitions, which (for Brevity ſake) ave compriz'd in one; becauſe a particular Expreſ- of them, would too much increaſe the intended k of the Book. I have therefore here exhibited a f Table, from whence the 24 Analogies may eaſily deduc'd.

The TABLE.

The Diameter of a Circle being 1, the Side of a	That may be inſcrib'd in that Circle, is	That may be circumſcrib'd about that Circle, is	That is e-qual to the Circle, is
Trigon	0.86603	1.73205	1.34704
Tetragon	0.70711	1.00000	0.88623
Pentagon	0.58778	0.72654	0.67578
Hexagon	0.50000	0.57735	0.54992
Heptagon	0.43390	0.48160	0.46500
Octagon	0.38268	0.41421	0.40393
Nonagon	0.34202	0.36397	0.35651
Decagon	0.30901	0.32491	0.31955

Thereſore, to find any of the *Quæſita* (or Thing ſought) in this Propoſition, this is

The RULE.

As 1, is to the reſpective Number in the Table; is the Diameter of any Circle given, to the *Quæſitu* or Thing ſought.

Example { 1. 2. 3.

What is the Side of a Trigon (or Equilater-Triangl
that { may be inſcribed in
may be circumſcribed about
is equal to } a Circle, who
Diameter is 7? Anſ. The Side of the { Inſcribed
Circumſcribed
Equal }
Trigon, is { 6. 06221.
12. 12435.
9. 42928.

Example { 4. 5. 6.

Wha

What is the Side of a Tetragon (or Geometrical quare) that $\left\{\begin{array}{l}\text{may be inſcribed in}\\ \text{may be circumſcribed about}\\ \text{is equal to}\end{array}\right\}$ a Circle, whoſe Diameter is 7? Anſ. The Side of the $\left\{\begin{array}{l}\text{Inſcribed}\\ \text{Circumſcribed}\\ \text{Equal}\end{array}\right\}$ Tetragon, is $\left\{\begin{array}{l}4.94977.\\ 7.00000.\\ 6.20361.\end{array}\right.$

And thus, as theſe ſix Propoſitions have been wrought, n the ſix preceding Examples; ſo, after the ſame manner, are all the other 18 to be wrought.

Note 1. Tho all the Analogies in the preceding Table re exact enough for Common Practice; yet, it muſt e confeſs'd, that ſome of them are not abſolutely, exact; neither indeed, is it poſſible they ſhould be ſo: the Reaſon is, Becauſe the *Datum* (or Thing given) being a Rational Number, many of the *Quæſita* (or Things ſought) will be Irrationals; that is, Numbers (if I may o call them) that cannot be expreſt by any Numbers, ntegral, or Fractional, but only by their Squares, or other higher Powers. *E. g.* If the Diameter of a Circle be Rational; the Side of its Inſcribed, or Circumſcribed Trigon, will be Irrational; but their Squares may be expreſt in Numbers. And ſo of others.

Note 2. If the Reader be ignorant of Decimals, (which et he ought not to be) he may reduce the (many) Analogies that are (in this Book) Decimally expreſt, nto the Common Accompt, by annexing ſo many Cyphers to the Unity, as there are Figures to the Right Hand of the Point in the Decimal Number. *E. g.* (In he preceding Table) Inſtead of ſaying, As 1, to 1.34704, e may ſay, As 10, to 13.4704; or, As 100, to 134.704; r, As 1000, 1.34704; or, As 10000, to 13470.4; or aſtly, As 100000, to 134704. But 3 or 4 Places being nice enough for Common Practice, (eſpecially by the Line) the Reader need take no more; rejecting all he reſt as uſeleſs; only if the next Decimal Figure ex-

exceed 5, he may add 1 to the laſt of the Figures h takes in. Thus, inſtead of ſaying, As 1, to 1.34704, he may ſay, As 100, to (not 134, but) 135; becauſe the next Decimal Figure is 7.

If the two Ratio's be both Decimal Numbers, then remove the Points further to the Right Hand equally, in both Ratio's. Thus, if the Analogy were, A 2.34704, to .88623, you may ſay, (for 'twill be th ſame thing) As 134704, to 88623. Or (making th Numbers leſs, by the former Part of this Note,) a 135, to 89.

PROP. VI.

The Circumference of a Circle being given; to find any o the Quæſita in the preceding Propoſition.

Here alſo (to avoid a Tædium) are 24 Propoſition exhibited in one; and all the 24 Analogies may be de duced from the Table in Prop. 5. by the following

RULE.

Firſt find the Diameters of the given Circle, by Prop 3. and then find any of the Quæſita, by Prop. 5.

Or more briefly, thus,

Say, as 3.14159, is to the Number (in the Table) reſpecting the Quæſitum; ſo is the Circumference o the given Circle, to the Quæſitum.

Thus, If the Circumference of the given Circle wer 21.99115, the Sides of its $\left\{\begin{array}{l}\text{Inſcribed}\\ \text{Circumſcribed}\\ \text{Equal}\end{array}\right\}$ Trigo and Tetragon, will be found to be the ſame as in th Examples of the preceding Propoſition. The Reaſon i plain, becauſe this Circle (according to *Metius*'s Analogy) has the ſame with that.

This being ſo very plain and eaſy, I think it nee no farther Exemplification.

PRO

PROP. VII.

The Side of any regular Polygon (from the Trigon to the Decagon) being given; To find the Diameter, or Circumference of its { *Inſcribed* / *Circumſcribed* / *Equal* } *Circle.*

Here (to avoid Tedioſity) I have compriz'd 48 Pro- oſitions in one; all whoſe ſeveral Analogies are alſo educible from the Table in Prop. 5. by the following ULES.

1. For the Diameter,

Say, As the reſpective Number (in the Table) under he Title { Inſcribed, / Circumſcribed, / Equal, } is to 1; ſo is the gi- en Side of the Polygon, to the Diameter of its { Inſcribed / Circumſcribed / Equal } Circle.

2. For the Circumference,

Say, As the reſpective Number (in the Table) under he Title { Inſcribed, / Circumſcribed, / Equal, } is to 3.14159; ſo is the iven Side of the Polygon, to the Circumference of s { Inſcribed / Circumſcribed / Equal } Circle.

Example.

If the Side of a Trigon be 1; What is the Dia- neter and Circumference of his Inſcribed, Circumſcri- ed, and Equal Circle? Anſ. The Diameter of its { Inſcribed / Circumſcribed / Equal } Circle, is { .577, &c. / 1.154, &c. / .742, &c. }

And the Circumference of its { Inſcribed, / Circumſcribed / Equal } Circle,

is { 1. 81, &c. / 3. 62, &c. / 2. 33, &c.

PROP. VIII.

The Side of any regular Polygon (from the Trigon to the Decagon) being given; To find the Side of any other regular Polygon (from the Trigon to the Decagon) equal thereto.

Here (to avoid Prolixity) are 56 Propoſitions, which I have included in one; *viz.* 7 relating to each Polygon, *e. g.* To find a Tetragon, a Pentagon, a Hexagon, &c. equal to a given Trigon. So alſo, To find a Trigon, a Pentagon, a Hexagon, &c. equal to a given Tetragon. And ſo of all the other Polygons in the Table in Prop. 5. from which Table all theſe 56 Propoſitions are alſo deducible, by the following

RULE.

Say, As the Number (under the Title *Equal*) againſt the given Polygon, is to the Number (under the ſame Title) againſt the Polygon, whoſe Side is ſought; ſo is the Side of the given Polygon, to the Side of the Polygon ſought.

Example 1.

Let it be requir'd to find a Tetragon (or Geometrical Square) equal to a Trigon (or Equilater Triangle) whoſe Side is 10 Here, I ſay, (from the Table) As 1.34704, is to .88623; ſo is 10 (the Side of the given Trigon), to 6.5790, the Side of the Tetragon ſought.

Example 2.

Let it be requir'd to find a Trigon, equal to a Tetragon, whoſe Side is 6 5790. Here, I ſay, As .88623 is to 1.34704; ſo is 6.5790, to 10, the Side of the Trigon ſought.

Theſe two Examples (I think) are ſufficient to make the Rule intelligible to any ordinary Underſtanding.

PROP. IX.

To find the Perpendicular of a Trigon (or Equaliter Triangle) the Side only being given.

The RULE.

As 1, is to .86603; ſo is the Side of a Trigon, to its Perpendicular.

Example.

If the Side of a Trigon be 10; What is the Length of its Perpendicular? Anſ. 8.6603.

PROP. X.

To find the Diagonal of a Tetragon (or Geometrical Square.)

The RULE.

As 1, is to 1.41774; ſo is the Side of a Tetragon, to its Diagonal.

Example.

If the Side of a Tetragon be 10; What is the Length of its Diagonal? Anſ. 14.1774.

PROP. XI.

Having the Chord and Verſed-Sine of an Arch given; To find the whole Diameter of that Circle, of which the given Arch was a part.

The RULE.

As the Verſed-Sine, is to 1; ſo is the Square of half the Chord, to a 4th. Which 4th added to the Verſed-Sine, gives the whole Diameter of the Circle.

Example.

Let there be a part of a Cheeſe, (cut off by a Right Line) whoſe *Chord* (i. e. the Right Line by which it was cut off) is 12 Inches, and its *Verſed-Sine* (i. e. the Perpendicular from the middle of the Straight Side, to the middle of the Arch) is 4 Inches; What was the whole Diameter of that Cheeſe? Anſ. 13 Inches.

PROP. XII.

To find the Parts of a Line, or Number, divided by Extream and Mean Proportion.

The RULE.

As 1, is to the given Number; ſo is $\left\{\begin{array}{l}.618\\ .382\end{array}\right\}$ to the $\left\{\begin{array}{l}\text{greater}\\ \text{leſſer}\end{array}\right\}$ Part of the Line or Number.

Example.

What are the Parts of 1000, divided by Extream and Mean Proportion? Anſ. The $\left\{\begin{array}{l}\text{greater}\\ \text{leſſer}\end{array}\right\}$ Part is $\left\{\begin{array}{l}618.\\ 382.\end{array}\right.$

Note. A Line, or Number, is ſaid to be divided by Extream and Mean Proportion; when the whole Line or Number is (in proportion) to the greater Part, as the greater Part is to the leſſer.

PROP. XIII.

To find any Chord in a Circle, that ſhall croſs the Diameter (at Right Angles) in any Point aſſigned.

The RULE.

If the given Part of the Diameter (by which the Chord is to paſs) be $\left\{\begin{array}{l}\text{greater}\\ \text{leſſer}\end{array}\right\}$ than the Radius, (or Semidiameter of the Circle,) then ſubſtract $\left\{\begin{array}{l}\text{the Radius from it,}\\ \text{it from the Radius,}\end{array}\right\}$ and the Remainder is the Co-Sine of half the Arch cut off by the Chord.

Then,

From the Square of the Radius, ſubſtract the Square of the Co-Sine; and the Remainder is the Square of half the Chord ſought.

Example.

If the whole Diameter of a Circle be 13 Inches; What is the Length of the Chord, croſſing the Diameter (at Right Angles) at the Diſtance of 4 Inches, from one End of the Diameter? Anſ. 12 Inches.

PROP. XIV.

To find the Trigonal, Tetragonal, Pentagonal, Hexagonal, Heptagonal, Octagonal, Nonagonal, and Decagonal Chords, of any Circle whoſe Diameter is given.

Here are 8 Propoſitions, which may all be ſolved by Prop. 5. foregoing: The Trigonal, Tetragonal, &c. Chords of a Circle, being the ſame with the Side of its inſcribed Trigon, Tetragon, &c.

PROP. XV.

The Diameter of a Sphere being given: To find the ſide of any of the Platonic Bodies that may be either
Inſcribed in
Circumſcribed about } *the given Sphere.*
or is Equal to

Here are 15 Propoſitions which (for Brevity ſake) I have Compriz'd in one; all whoſe ſeveral Analogies, (with many more uſed in the following Propoſitions) may be deduced from this following

TABLE.

The Diameter of a Sphere being Unity, the Side of a	That may be Inſcribed in the Sphere, is	That may be Circumſcribed about the Sph. is,	That is Equal to the Sph. is
Tetraëdron.	0.816497	2.44948	1.64417
Octaëdron.	0.707107	1.22474	1.03576
Hexaëdron	0.577350	1. ——	0.80610
Icoſaëdron.	0.525731	0.66158	0.62153
Dodecaëdron.	0.356822	0.44903	0.40883

Now,

To find any of the Quæſita (or Things ſought) in this Propoſition; this is

The RULE.

Say, As 1, is to the Number (in the Table) reſpecting the Quæſitum (or Thing ſought); ſo is the Diameter of the given Sphere, to the Quæſitum.

Example 1.

What is the Side of a Tetraedron, that may be inſcribed in a Sphere, whoſe Diameter is 10? Anſ. 8.16497. For, As 1, (the ſuppoſed Diameter of a Sphere) is to .816497; (the Side of a Tetraedron that may be inſcribed in that Sphere, whoſe Diameter is 1,) ſo is 10 (the Diameter of the given Sphere) to 8.16497 (the Side of the Tetraedron that may be inſcribed in that Sphere whoſe Diameter is 10.)

Example 2.

What is the Side of a Tetraedron, that may be circumſcribed about a Sphere, whoſe Diameter is 10? Anſ. 24.4948. For, As 1 : 2.44948 : : 10 : 24.4948.

Example 3.

What is the Side of a Tetraedron, that is equal (in Solidity) to a Sphere whoſe Diameter is 10? Anſ. 16.4417. For, As 1 : 1.64417 : : 10 : 16.4417.

Thus I have Exemplify'd 3 of the 15 Propoſitions; the other 12 are to be wrought after the ſame manner.

Note. If the Reader be ſo dull, as not to apprehend the Analogy already laid down, (for finding the Quæſita in this Propoſition,) let him take it in other words, thus;

As 1, is to the Number (in the Table) againſt any of the Platonic Bodies, and under the Title $\left\{\begin{array}{l}\text{Inſcribed;}\\ \text{Circumſcribed;}\\ \text{Equal;}\end{array}\right\}$ ſo

is the given Diameter of any Sphere, to the de of that reſpective Platonic Body when it is
inſcribed in
circumſcribed about
equal to
the given Sphere.

PROP. XVI.

he Circumference of a Sphere being given; To find any of the Quæſita in the 15th Propoſition.

Here are alſo 15 Propoſitions, which may all be ſolved (the help of the Table in Prop. 15. and) the fol-
wing

RULE.

Firſt find the Diameter of the given Sphere by Prop. 3. this Chapter; and then find any of the Quæſita Prop. 15.

Or more briefly thus,

Say, As 3.14159, is to the Number (in the Table) inſt any of the Platonic Bodies, and under the
tle
Inſcribed;
Circumſcribed;
Equal;
ſo is the given Circumference any Sphere, to the Side of that reſpective Platonic dy when it is
inſcribed in
circumſcribed about
equal to
the given here.

Example
1.
2.
3.

If the Circumference of the Sphere be 31.4159; hat is the ſide of its
Inſcribed
Circumſcribed
Equal
Tetraedron?

ſw.
8.16497
24. 4948
16. 4417
the ſame that was found in the

Examples of the preceding Propoſition. The Reaſon is, becauſe this Sphere has the ſame Diameter with that.

PROP. XVII.

The ſide of any one of the 5 Platonic Bodies bein given; to find the Diameter, or Circumference of it

Inſcribed
Circumſcribed } *Sphere.*
Equal

To avoid Prolixity, I have included 30 Propoſition in one; which may be all ſolved by help of the Tabl in Prop. 15. and the following Rules.

1. If the Diameter of the Sphere be ſought this is

The RULE.

As the reſpective Number (in the Table) under th

Inſcribed,
Title { Circumſcribed, } is to 1; ſo is the given Side o
Equal,

Inſcribed
the Platonic Body, to the Diam. of its { Circumſcrib.
Equal

Sphere.

2. If the Circumference of the Sphere be ſough this is

The RULE.

As the reſpective Number (in the Table) under th

Inſcribed,
Title { Circumſcribed, } is to 3.14159; ſo is the g
Equal,

ven Side of the Platonic Body, to the Circumferen

Inſcribed
of its { Circumſcribed } Sphere.
Equal

1.
Example { 2.
3.

If the Side of a Tetraedron be 10; What is the iameter and Circumference of its
Inſcribed
Circumſcribed
Equal

here? Anſ. The Diameter of its
Inſcrib'd
Circumſcrib'd
Equal

here is
4.084
12.24
6.08

and the Circumference of its

Inſcribed	Sphere is	12.82.
Circumſcribed		38.47.
Equal		19.10.

PROP. XVIII.

he Side of any one of the Platonic Bodies being given; To find the Side of any of the other Platonic Bodies, equal (in Solidity) thereto.

Here are 20 Propoſitions compriz'd in one; *viz.* relating to each Platonic Body: *e. g.* To find an ſta-, Hexa-, Icoſa-, and Dodeca-edron, equal to a ven Tetraedron. So likewiſe, To find a Tetra-, Hexa-, oſa-, and Dodecaedron, equal to a given Octaedron. nd ſo of the reſt. And all theſe 20 Propoſitions are ſol- ble from the Table in Prop 15. by the following

RULE.

As the Number (under the Title *Equal*) againſt the ven Platonic Body, is to the Number (under the ſame tle) againſt the Platonic Body whoſe Side is ſought; is the Side of the Platonic Body given, to the Side the Platonic Body ſought.

Example.

Let it be requir'd to find the Side of a Tetraedron, t ſhall be equal (in Solidity) to a Dodecaedron, whoſe le is 10.

Here I ſay, (from the Table) As .40883, is to 1.64417; is 10 the given Side of the Tetraedron, to 40.21 Side of the Tetraedon ſought.

Thus,

Thus, Kind Reader, I have (in this Chapter) giv thee Rules for the Solution of 249 Propoſitions; (viz 160 from the Table in Prop. 5, 80 from the Table i Prop. 15. and 9 others;) and all, I think, as plai and intelligible, (even to the meaneſt Capacity, that i but diligent and induſtrious,) as if I had ſaid ten tim as much.

I ſhould now ſay ſomething of taking Heights and Diſtances; but, I think, this Chapter is already long enough I ſhall therefore refer it to the next.

CHAP. II.

Of Altimetry, and Longimetry: or the Uſefulneſs of the Line of Numbers, in takin Hights and Diſtances.

I Shall not here teach the whole Art of taking Heigh and Diſtances; for in ſo doing I ſhall ſtep be ſide the Bridge: I ſhall therefore keep to my Tit by ſhewing only the Excellency of the Line of Number in this Affair.

Heights and Diſtances may be taken by different way almoſt innumerable, both with and without Inſtrument Of Inſtruments I ſhall mention only the Quadrant because *that* (as it may be, and is commonly made,) i the moſt ſimple Inſtrument in the Mathematicks, a well known almoſt to every one.

SECT. I.

Of taking Heights by the Quadrant.

Heights are taken by the Quadrant, either by the Degrees on the Limb, or by the Diviſions on the Quadra Where Note,

1. That if you work by the Degrees on the Limb

ou muſt make uſe of the Table of Natural Sines and angents.

2. That if you work by the Quadrat; then that ale (of the Quadrat) which is next to the Sights (of Quadrant, is (by me) call'd the Scale of Right adows; and the other I call the Scale of Contrary adows. This I thought fit to ſpecify, becauſe Au- ors differ in their Denomination. So this being pre- is'd, I proceed to

PROP. I.

o take the Height of an acceſſible Object, by the Quadrat of the Quadrant.

The RULE.

(1.) If (when looking through the Sights of the Qua- ant, at the Apex of the Object) the Thread fall on Right Shadow; ſay, As the Parts cut by the Thread, to the Radius of the Quadrat, (*i.e.* the whole Num- r each Side of the Quadrat is divided into); ſo is the iſtance from the Station to the Object, to the Height the Object above the Horizontal Line of the Eye. t, (2.) If the Thread fall on the contrary Shadow; en ſay, As the Radius of the Quadrat, is to the Parts t by the Thread; ſo is the Diſtance from the Object the Station, to the Height of the Object above the ye, as before.

Example $\left\{\begin{matrix}1.\\2.\end{matrix}\right.$

Suppoſe the Radius of the Quadrat be 100, and the arts of the $\left\{\begin{matrix}\text{Right}\\\text{Contrary}\end{matrix}\right\}$ Shadow cut by the Thread ; and the Diſtance of the Object from the Station $\left.\begin{matrix}40\\160\end{matrix}\right\}$ Foot; What is the Hight of the Object? nſ. 80 Foot above the Level of the Eye. For,

s $\left\{\begin{matrix}50 : 100 :: 40 : 80.\\100 : 50 :: 160 : 80.\end{matrix}\right.$

Note 1. The Diſtance from the Station to the Object, muſt be taken, to a Perpendicular under that Point of the Object, ſeen through the Sights, when the Obſervation was made; which in Steeples, *&c.* will be the middle of the Object; but in ſuch things as are flat on the Top, it will be that ſide next the Station.

2. That having made Obſervation at the Apex of the Object; you ſhould alſo make an Horizontal Obſervation; making a Mark on the Object where the Viſual Ray falls, and meaſuring the Diſtance from this Mark to the Ground; add it to the Height before found, ſo ſhall you have the true Height of the Object from the Ground.

PROP. II.

Another way to take the Height of an acceſſible Object, by the Quadrat of the Quadrant.

The RULE.

If (the Sun ſhining through the Sights of the Quadrant) the Thread fall on the $\left\{\begin{array}{l}\text{Right}\\ \text{Contrary}\end{array}\right\}$ Shadow, ſay, As the $\left\{\begin{array}{l}\text{Parts cut, is to the Radius of the Quadrat;}\\ \text{Radius of the Quadrat, is to the Parts cut;}\end{array}\right\}$ ſo is the Length of the Shadow of the Object, to the Height of the Object above the Ground.

Example $\left\{\begin{array}{l}1.\\ 2.\end{array}\right.$

Let the Radius of the Quadrat be 100, and the Parts of $\left\{\begin{array}{l}\text{Right}\\ \text{Contrary}\end{array}\right\}$ Shadow cut by the Thread, 50, and the Length of the Shadow $\left\{\begin{array}{c}30\\ 120\end{array}\right\}$ Feet; What is the Height of the Object? Anſ. 60 Feet. For, As

$$\left\{\begin{array}{l}50 : 100 :: 30 :\\ 100 : 50 :: 120 :\end{array}\right\} 60.$$

Note. For taking Heights this way, ſuch a Time of the Day ſhould be choſen, as that the Shadow of the

Object

bject may fall (as near as may be) upon the level round: For if the Ground whereon the Shadow falls, (conſiderably) recline from, or incline towards the bject; as the Shadow will be thereby longer or orter, ſo will the Height of the Object be found more leſs than the Truth.

P R O P. III.

To take the Height of an inacceſſible Object, by the Quadrat of the Quadrant.

The R U L E.

This Propoſition is perform'd by two Stations; at ch of which, take a View of the Apex of the Object, rough the Sights of the Quadrant; then, if (in any the Stations) the Thread fall upon the $\left\{\begin{matrix}\text{Right}\\ \text{Contrary}\end{matrix}\right\}$ adow; ſay, As the $\left\{\begin{matrix}\text{Radius of the Quadrat, is to the}\\ \text{Parts cut, is to the Radius of the}\end{matrix}\right.$ $\left.\begin{matrix}\text{rts cut;}\\ \text{uadrat;}\end{matrix}\right\}$ ſo is 1, to a 4th. Having thus found a h Proportional for each Station; ſay, As the Difference of theſe 4ths, is to 1; ſo is the Diſtance betwixt e two Stations, to the Height of the Object.

Example $\left\{\begin{matrix}1.\\ 2.\end{matrix}\right.$

Suppoſe the Radius of the Quadrat be 100; and that the firſt Station, the Parts cut by the Thread, be $\left.\begin{matrix}50\\ 20\end{matrix}\right\}$ of Right Shadow; and at the ſecond Station, ppoſe the Parts cut be $\left\{\begin{matrix}50\\ 60\end{matrix}\right\}$ of Contrary Shadow; d ſuppoſe further, that the Diſtance between the two ations be $\left\{\begin{matrix}75\\ 88\end{matrix}\right\}$ Feet; What is the Height of the Ob- ct? Anſ. $\left\{\begin{matrix}50\\ 60\end{matrix}\right\}$ Feet.

PROP.

PROP. IV.

To take the Height of an acceſſible Object, by the Degrees in the Limb of the Quadrant.

The RULE.

As the Co-ſine of the Degrees, cut by the Thread, (when the Eye through the Sights, ſees the Apex of the Object) is to the Sine thereof; ſo is the Diſtance between the Station and the Object, to the Height of the Object, above the Horizontal Line of the Eye.

Example.

If the Degrees cut by the Thread be 30, and the Diſtance from the Station to the Object be 86.6 Feet; What is the height of the Object ? Anſ. 50 Feet. For, as 8606 (the Co-ſine of 30 Degrees,) is to 5000 (the Sine thereof ;) ſo is 86.6 Feet (the Diſtance from the Station to the Object,) to 50 Feet, the height of the Object.

Note: The diſtance from the Station to the Object, muſt be taken acccording to the Note, in *Prop*. 1.

PROP. V.

To take the height of an inacceſſible Object, by the Degrees on the Limb of the Quadrant.

The RULE.

This Propoſition is performed by 2 Stations; at each of which take a view of the Apex of the Object, thro the Sights of the Quadrant, and Note the Degrees cut by the Theead ; then, from the Degrees cut at the neareſt Station to the Object, Subſtract the Degrees cut at the fartheſt Station from the Object, noting the Remainder: Then ſay, as the ſine of this Remainder, is to ſine of the Degrees cut at the fartheſt Station ; ſo is the Diſtance between the 2 Stations, to a 4th. Then as the Radius, is to this 4th ; ſo is the ſine of the Degrees cu

at

t the neareſt Station, to the height of the Object above
he Horizontal Line of the Eye, at that Station.

Example 1.

If the Degrees (cut by the Thread) at the neareſt
Station were 45, and at the fartheſt 30; and the Di-
ance between the two Stations 30 Feet; What is the
eight of the Object? Anſ. 40.757 Feet. For, as
602. (the ſine of 15 Degrees, the difference of De-
rees cut at each Station,) is to 5000, (the ſine of 30
egrees, cut at the fartheſt Station, ſo is 30 Feet (the
iſtance between the two Stations) to 57.64 Feet (a
th.) Then again, as 10000 (the Radius,) is to 57.64
he 4th;) ſo is 7071 (the ſine of 45 Degrees, cut at the
eareſt Station,) to 40.757 Feet, the Height of the
bject.

PROP. VI.

nother way to take the height of an inacceſſible Object, by the Degrees on the Limb of the Quadrant.

The RULE.

Having taken your firſt Station, as near the Object
conveniently you may, and made Obſervation of the
egrees cut (by the Thread) on the Limb of the Qua-
rant; then for the 2d Station, go back (in a Right-
ine with the Object and firſt Station) ſo far, that
e Degrees cut by the Thread may be but juſt half ſo
any as were cut at the firſt Station. Then ſay, as the
adius, is to the ſine of the Degrees cut at the 1ſt Station;
is the Diſtance between the 2 Stations, to the height
the Object above the level of the Eye at the firſt
ation.

Example.

If the Degrees cut at the neareſt Station to the Ob-
ct were 80, and the Diſtance between the two Stations
o Feet; What is the height of the Object? Anſ.

98.48

98.48 Feet. (*i. e.* almoſt 98½ Feet) for, for as 100000: 9848 :: 100 : 98.48.

Note: In this and the preceding Propoſition, you ought to chooſe as level Ground(for the diſtance between the Stations) as you can.

PROP. VII.

Another more general way, by any two Stations, taken at Random.

The RULE.

Having made Obſervation at each Station; then ſay, as the difference of the Co-Tangents of the Degrees cut at each Station, is to the Diſtance between the 2 Stations; ſo is the Radius, to the height of the Object.

Example.

Let the Degrees cut at the neareſt Station be 80, and at the fartheſt Station 40, and the diſtance between the Stations 150 Feet; What is the height of the Object? Anſw. 147.72 Feet. For the Co-Tangent of 80 Degrees is 1763, of 40 Degrees is 11917. their Difference is 10154. Then I ſay, as 10154 : 10000 :: 150 : 147.72.

SECT. II.

Of taking hieghts by the Projected, or Reflected Image of the Object.

The projected Image of an Object is the *Umbra* or Shadow of it cauſed by the Sun, *&c.* And the Reflected Image is the *Icon* or Repreſentation of it in Water, *&c.* Which is alſo commonly call'd a Shadow.

Now Heights may be taken ſeveral ways by the Shadow of the Object; but I ſhall(in this place)mention only two or three of them.

PROP. I.

To take the height of an acceſſible Object, by its Shadow made by the Sun or Moon, and the help only of a Line and Plummet.

The

The RULE.

Say, As the Length of the Shadow of the Line and lummet, is to the Length of the Line and Plummet; is the Length of the Shadow of the Object, to the eight of the Object above the Ground.

Example.

If the Length of the Line and Plummet be 5 Feet, d the Length of its Shadow be 3 Feet, and the Length the Shadow of the Object be 30 Feet; What is the eight of the Object? Anſ. 50 Feet. For, As :5 : : 30 : 50.

Note (1.) That the Length of the Shadow of the bject, ſhould be taken to a Perpendicular under that oint of the Object which gives the longeſt Shadow; hich in Steeples, &c. will be the Middle of the Object; t in ſuch things as are flat on the Top, it will be that le next the Shadow.

(2.) That the Length of the Shadow of the Line d Plummet, (ſuſpended from the Hand, or the like) ght to be taken on the ſame Ground on which the adow of the Object falls; for ſo the Acclivity or De- ivity of the Ground, will cauſe no Variation.

(3.) That this Propoſition might alſo be wrought by e help of the Quadrant, as in Prop. 2. of Sect. 1. But e Rule deliver'd in this Propoſition is to be prefer'd to at, as being more accurate.

PROP. II.

To take the Height of an acceſſible Object, by its Shadow in a Baſon of Water.

The RULE.

Having ſet down the Baſon of Water any where before e Object; go back (in a Right Line with the Object d Baſon) till the Shadow of the Apex of the Object ppears in the Middle of the Baſon: Then ſay, As the Diſtance from the Middle of the Baſon to your Station, is to the Height of your Eye above the Level of the Baſon; ſo is the Diſtance from the Object to the Baſon, to its Height above the Level of the Baſon.

Example.

Let the Diſtance from the Baſon to the Station be 10 Feet, and the Height of the Eye 5 Feet, and the Diſtance from the Baſon to the Object 100 Feet; What is the Height of the Object? Anſ. 50 Feet. For, As 10 : 5 :: 100 : 50.

Note (1.) That in taking a Height by this Method, you ought to chooſe ſuch a Station, as that the Space between it and the Object, be as level Ground as may be.

(2.) That the Diſtance between the Baſon and the Object, ſhould be taken to a Perpendicular under that Point of the Object which you ſaw in the Middle of the Baſon. *v.* Note 1. of Prop. 1. of Sect. 2.

PROP. III.

To take the Height of an inacceſſible Object, by its Shadow in a Baſon of Water.

The RULE.

Having made one Obſervation, as in the preceding Propoſition; mark the Station of the Baſon, and alſo your own Station. Then remove the Baſon backwards, in a Right Line from the Object, (any Diſtance that you pleaſe) and make (a ſecond) Obſervation as before. Then ſay, As the Height of your Eye (above the Level of the Baſon) at your $\left\{\begin{array}{l}\text{firſt}\\ \text{ſecond}\end{array}\right\}$ Station, is to the Diſtance from the Middle of the Baſon to your Station; ſo is 1, to a 4th. Having thus found a 4th Proportional for each Station; ſay, As the Difference between theſe 4ths, is to 1; ſo is the Diſtance between the two Stations of the Baſon, to the Height of the Object.

Example.

If in the $\left\{\begin{array}{l}\text{firſt}\\ \text{ſecond}\end{array}\right\}$ Obſervation, the Diſtance be-een the Baſon and your Station be $\left\{\begin{array}{c}5\\ 15\end{array}\right\}$ Feet, and e Height of the Eye in each Obſervation 5 Feet, and Diſtance between the two Stations of the Baſon o Feet; What is the Height of the Object? Anſ. Feet.

Note. That the firſt Note in the preceding Propoſition, kes place alſo in this.

So, let this ſuffice (at this time) for Altimetry, or king of Heights. I come now to

SECT. III.

Of Longimetry, or Taking Diſtances.

As *Heights*, ſo alſo *Diſtances*, may (as was before ted) be taken by different Ways, almoſt innumerable. hall here mention only ſome few of the moſt eaſy practicable Ways.

PROP. I.

o take the laterial Diſtance of an Object, by the Quadrat of the Quadrant.

The RULE.

Having, at two different Stations, taken a View of the ex of the Object, through the Sights of the Quadrant, noted the Diviſions cut (by the Thread) at each tion: Then, find the Height of the Object, by Prop. of Sect. 1. Then, to find the Diſtance of the Object n any of the Stations, ſay, As the $\left\{\begin{array}{l}\text{Radius of the Quadrat, is to the Parts of Right Shadow cut;}\\ \text{Parts of the Contrary Shadow cut, is to the Radius of the Quadrat;}\end{array}\right\}$. s the Height of the Object, to its Diſtance.

Example.

If the Radius of the Quadrat be 60, and the Par of Contrary Shadow cut at the neareſt Station (to th Object) be 5, and at the fartheſt Station (from the O ject) 4, and the Diſtance between the two Stations 150 Feet; What is the Diſtance of the Object, fro the farther Station? Anſ. The Height of the Obj will be found (by Prop. 3. of Sect. 1.) to be 50 Fee and (from thence) its Diſtance from the farther Statio will be found to be 750 Feet. For, As 4 : 60 : : 50 : 75

PROP. II.

To take the laterial Diſtance of an Object, by the Deg on the Limb of the Quadrant.

The RULE.

Firſt find (by Prop. 5. of Sect. 1.) the Height of t Object above the Horizon of the neareſt Station. Th ſay, As the Sine of the Degrees cut (by the Thread) the neareſt Station, is to the Co-ſine thereof; ſo is Height of the Object (now found) to its Diſtance fr the neareſt Station.

Example.

If the Degrees cut at the neareſt Station be 5, and the fartheſt 4, and the Diſtance between the two S tions be 150 Feet; What is the Diſtance of the Obj from any of the Stations? Anſ. The Height of Object will be found (by Prop. 5. of Sect. 1.) to 52.17 Feet; and from thence (by the preſent Prop tion) its Diſtance from the neareſt Station, will be fo to be 596 Feet. To which, if you add 150 Feet, Diſtance between the two Stations, it makes 746 F for the Diſtance between the Object and the fart Station.

PROP. III.

o take the laterial Diſtance of an Object, by its Shadow in a Baſon of Water.

The RULE.

Firſt find the Height of the Object, by Prop. 3. of t. 2. Then ſay, As the Height of your Eye (in any your Stations), is to the Diſtance of your Station m the Baſon; ſo is the Height of the Object (now nd) to its Diſtance from the Baſon.

Example.

If in the firſt Obſervation, the Diſtance between the ſon and your Station, be 5 Feet, and in the ſecond Ob- vation 10 Feet; and the Height of the Eye in each tion 5 Feet; What is the Diſtance of the Object n the fartheſt Station? Anſ. 100 Feet.

I might here ſhew many more Ways to take Heights Diſtances; but at this time let theſe ſuffice.

CHAP. III.

f Planimetry, or the Menſuration of Superficial Figures by the Line.

Shall here forbear to lay down the Definitions of Geometrical Figures, for the Reaſon mention'd in Proeme of this Book. And therefore I ſhall fall ectly to the Matter in Hand; and ſhew how in

PROP. I.

o find the Area or Superficiality of any Paralellogram, (whether Right-Angl'd, as the Geometrical Square and

Oblong; or Oblique-Angl'd, as the Rhomb and Rhomboid;) as alſo of any Right-lin'd Triangle, (whether Equilateral, Iſoſcle, or Scalene;) and alſo of a Trapezia.

Theſe are all the Right-lin'd plain Figures in Geometry, (except Polygons;) of which hereafter; I ſhall therefore for theſe, lay down a brief Table of Centres or Points on the Line, by which and the following Rules, you may find their Area, in any uſual Meaſure, as Inches, Feet, Yards, Squares, Perches, or Miles.

Breadth given in	Length given in	Area requir'd in	The Centre is at
Any Meaſure	the ſame.	the ſame.	1.
Inches.	Inches.	Feet	144.
		Yards	1296.
		Squares	14400.
		Perches.	39204.
		Acres	6272640.
		Miles	4014489600.
	Feet.	Feet	12.
		Yards	108.
		Squares	1200.
		Perches	3267.
		Acres	522720.
		Miles	334540800.
	Yards.	Yards	36.
		Squares	400.
		Perches	1089.
		Acres	174240.
		Miles	111513600.
	Perches.	Perches	198.
		Acres	31680.
		Miles	20275200.
	Miles.	Miles	63360.

A Continuation of the preceding Table.

Breadth given in	Length given in	Area requir'd in	The Centre is at
eet.	Feet.	Yards	9.
		Squares	100.
		Perches	272.25
		Acres	43560.
		Miles	27878400.
	Yards.	Yards	3.
		Squares	33.333, &c.
		Perches	90.75
		Acres	14520.
		Miles	9292800.
	Perches.	Perches	16.5.
		Acres	2640.
		Miles	1689478.78
	Miles.	Miles	5280.
ards.	Yards.	Squares	11.1111, &c.
		Perches	30.25
		Acres	4840.
		Miles	3097600.
	Perches.	Perches	5.5
		Acres	880.
		Miles	563200.
	Miles.	Miles	1760.
rches.	Perches.	Acres	160.
		Miles	102400.
	Miles.	Miles	320.

The Uſe of the preceding Table.

When a Superficies is to be meaſur'd, conſider what eaſures the Dimenſions are given in, and in what Mea- re; the Area is requir'd; and accordingly enter the able; finding in the firſt Column the Denominative eaſure of the given Breadth; and (within that Line of Connection) in the ſecond Column, find the Denominative Meaſure of the given Length; and (withi that Line of Connection) in the third Column, fin the Denominative Meaſure of the requir'd Area; an againſt it in the fourth Column is a Number, which call the Centre; becauſe, if at that Number on th Line, a Point or Centre be made, it will be of conſtant Uſe, in ſolving all Queſtions that have the ſam *Data* and *Quæſitum*. The Number which I call th Centre, being thus found; this is the

General RULE.

As that Tabular Number, is to the given Breadth ſo is the given Length, to the Area ſought.

Therefore,

Always extend the Compaſſes, from the Centre t the given Breadth; the ſame Extent of the Compaſſ will reach (being apply'd the ſame way) from the given Length, to the Area requir'd.

Example.

Let it be requir'd to meaſure a Rectangl'd Oblon Parallelogram, (as a Plank, Board, or the like,) whc (given) Breadth is 10 Inches, and Length 18 Feet and whoſe Area is requir'd in Feet.

Here (becauſe the Breadth is given in Inches) I fin Inches in the firſt Column of the Table; and (withi that Line of Connection) in the ſecond Column (because the Length is given in Feet) I find Feet; an (within that Line of Connection) in the third Colum (becauſe the Area is requir'd in Feet) I find Feet; an againſt it in the fourth Column I find 12. which is no the Centre; and is always ſo when the *Data* and *Qu ſitum* is the ſame as it is now. Therefore (by the G neral Rule above,) I ſay, As 12 is to the Breadth i Inches; ſo is the Length in Feet, to the Area in Feet

So, in this Example, the Extent from 12 (the Centr to 10, (the Breadth in Inches) will reach the ſame wa from 18 (the Length in Feet) to 15, the Area in F requir'd.

So, let what has been ſaid (together with the follow-
g Notes) ſuffice for the Explanation and Uſe of the
able; for it being ſo plain in it ſelf, I think it needs
farther Exemplification.

Note 1. If the Superficies to be meaſur'd, be a Geo-
etrical Square; any Side may be accounted the Breadth,
d the other the Length.

2. If it be an Oblong, the Breadth and Length are
ſily known.

3. If it be a Rhomb; one ſide is accounted the
ength, and a Perpendicular let fall from one Angle
that ſide, is the Breadth.

4. If it be a Rhomboid; one of the longeſt Sides is
e Length, and a Perpendicular (as in the Rhomb) is
e Breadth.

5. If it be a Triangle, (of what kind ſoever,) the
aſe is the Length, and half the Perpendicular is the
eadth.

6. If it be a Trapezia; the longeſt Diagonal is the
ength, and half the Sum of the Perpendiculars, (let
ll from the other Angles to that Diagonal,) is the
readth.

7. I might here ſhew how the Circle, and any Regu-
r Polygon, might be meaſur'd by the preceding Table;
viz. thus; For the Circle account half the Diameter
r the Breadth, and half the Circumference for the
ength. And, for a Regular Polygon, account the *Linea*
endens (which is a Perpendicular let fall from the Centre
the middle of one ſide,) for the Breadth, and half
e Circumference for the Length.) But for the Circle,
d ſome Regular Polygons, I ſhall exhibit other Rules
the following Propoſitions.

Thus, in this firſt Propoſition, I have compriz'd 50
r each Figure therein mention'd; and they being
in Number, (*viz.* the Geometrical Square, the Ob-
ng, the Rhomb, and Rhomboid, Triangle, Trapezia,
ircle, and Polygon,) make in the whole 400 ſeveral
Propo-

Propoſitions; each of which are (I think) as plain and intelligible, as if they had been all handl'd diſtinctly.

PROP. II.

To find (in any uſual Meaſure) what Length any Parallelogram muſt be, to make a Superficial Foot, Yard, Perch, &c. the Breadth being given in any (uſual) Meaſure.

The RULE.

Enter the Table in Prop. 1. finding in the firſt Colum the Denominative Meaſure of the given Breadth; an (within that Line of Connection) in the ſecond Column find the Denominative Meaſure of the requir'd Length and (within that Line of Connection) in the third Column, find the Denomination of that Superficial Meaſure whoſe Length is requir'd; and againſt it in th fourth Column, is a Number, which I ſhall call th Tabular Number: Which Number being thus found this is the

General RULE.

As the given Breadth, is to the Tabular Numbe ſo is 1, to the Length ſought.

Example.

Let there be Parallelogram, whoſe (given) Breadth 12 Inches; and let it be requir'd to find the Lengt in Inches to make a Superficial Yard.

Here (becauſe the Breadth is given in Inches) I fin Inches in the firſt Column of the Table; and (following the Rule) in the ſecond Column, (becauſe th Length is requir'd in Inches) I find Inches; and in th third Column (becauſe the Superficial Meaſure, who Length is requir'd, is a Yard,) I find Yards; and again it, in the fourth Column, I find 1296. Which is th Tabular Number for this Queſtion; and for all othe of the ſame *Data* and *Quæſitum*. Therefore (by th General Rule above) I ſay, As 12 (the given Breadth

to 1296, (the Tabular Number); ſo is 1, to 108,
e Length in Inches (to make a Superficial Yard) re-
uir'd.

Again, If from the ſame *Data*, the Length had been
quir'd in Feet; the Tabular Number (by the ſame
ethod) would be found to be 108; and from thence,
e Length requir'd, would be found to be 9 Feet.

Again, If the Length (from the ſame *Data*) be re-
uir'd in Yards; the Tabular Number will be found
be 36, and the Length requir'd 3 Yards.

This Propoſition being ſo very plain, (and I affect-
g Brevity) I forbear to add any more Examples.

Note. If this Propoſition be (as it may) apply'd to
the Figures mention'd in Prop. 1. then here will
ſo be 400 Problems, and all reſolvable from the Ta-
e in Prop. 1. and the Rules above.

PROP. III.

To find the Area or Superficiality of a Circle.

$$\text{As}\left\{\begin{array}{l}14,\text{ to }11;\\ 1.27324,\text{ to }1;\\ 452,\text{ to }355;\end{array}\right\}\text{ſo is the Square of the Diame-}$$

$$\text{, to the Area, according to}\left\{\begin{array}{l}\textit{Archimedes.}\\ \textit{Van Culen.}\\ \textit{Adrianus Metius.}\end{array}\right.$$

Otherwiſe,

$$\text{As}\left\{\begin{array}{l}7,\text{ to }22;\\ 113,\text{ to }355;\\ 1,\text{ to }3.14159;\end{array}\right\}\text{ſo is the Square of the Semi-}$$

$$\text{ameter, to the Area, according to}\left\{\begin{array}{l}\textit{Archimedes.}\\ \textit{Adrianus Metius.}\\ \textit{Van Culen.}\end{array}\right.$$

Otherwiſe,

$$\text{As}\left\{\begin{array}{l}88,\text{ to }7;\\ 1,\text{ to }.07958;\end{array}\right\}\text{ſo is the Square of the Circum-}$$

ence, to the Area.

Otherwiſe,

As 1, is to the Semi-Diameter; ſo is the Semi-Circumference, to the Area.

Otherwiſe,

As 4, is to the Diameter; ſo is the Circumferenc to the Area.

Or more briefly, thus;

Always extend the Compaſſes from 1, to the (given) Diameter of the Circle; the ſame Extent being turn'd twice (the ſame way) from $\left\{\begin{array}{l}.7857\\ .7853\\ .7854\end{array}\right\}$ will reach t the Area of the Circle; according to $\left\{\begin{array}{l}\textit{Archimedes.}\\ \textit{Adri. Metius.}\\ \textit{Van Culen.}\end{array}\right.$

Note. The Unit (in this Caſe) is beſt taken at 1 in the Middle of the Line; for ſo .785, &c. will be a 7.85, &c. on the firſt Part of the Line.

Example.

If the Diameter of a Circle be 10; What is the Ar thereof? Anſ. $\left\{\begin{array}{l}78.57\\ 78.53\\ 78.54\end{array}\right\}$ according to $\left\{\begin{array}{l}\textit{Archimedes.}\\ \textit{Adri. Meti}\\ \textit{Van Culen.}\end{array}\right.$

PROP. IV.

To find the Area or Superficiality of the Sector of Circle.

The RULE.

As 1, is to the Semi-Diameter of the Circle of whi it is a Sector; ſo is the Semi-Circumference of the Ci cular Part, to the Area of the Sector, ſought.

Example.

If the Semi-Diameter of the Circle be 7, and t Semi-Circumference of the Circular Part be 8; wh is the Area of that Sector? Anſw. 56.

PRO

PROP. V.

To find the Area or Superficiality of the Segment of a Circle.

The RULE.

(1.) Meaſure it (by Prop. 4.) as the Sector of a ircle, only if the Segment be $\left\{\begin{matrix}\text{leſſer}\\ \text{greater}\end{matrix}\right\}$ than a Semi-ircle, $\left\{\begin{matrix}\text{Subſtract from}\\ \text{add to}\end{matrix}\right\}$ the Area ſo found, the Area f an Iſoſcle Triangle, whoſe Baſe is the Chord, and Per-endic. the Exceſs of the $\left\{\begin{matrix}\text{Verſed Sine above the Radius.}\\ \text{Radius above the Verſed Sine.}\end{matrix}\right.$

(2.) But, the common *Data* for meaſuring the *Segent* of a Circle, being the *Chord* and *Verſed Sine*; before he *Sector* can be meaſured, the Radius (or Semi-Diaeter) and ½ the Circumference of the Arch, muſt be ound; (they being the common *Data* for meaſuring Sector;) thus,

(3.) To find the Radius, ſay,

As the Verſed Sine, is to the Square of ½ the Chord; o is 1 to a 4th, which added to the Verſed Sine, gives he whole Diameter; half of which is the Radius.

(4.) To find half the Circumference of the Arch of he Segments, this is

The RULE.

If the Segment be $\left\{\begin{matrix}\text{leſſer}\\ \text{greater}\end{matrix}\right\}$ than a Semi-Circle, ay, as the Radius added to half the Exceſs of he $\left\{\begin{matrix}\text{Radius above the Verſed Sine,}\\ \text{Verſed Sine above the Radius,}\end{matrix}\right\}$ is to half the hord; ſo is 86, to the $\left\{\begin{matrix}\text{———————}\\ \text{Complement to 180 of the}\end{matrix}\right\}$ alf Circumference of the Arch, in Degrees.

(5.) Then, (the Diameter being found as above) nd the Circumference of the whole Circle, (by Prop. 1.

1. of Chap. 1.) Then ſay, as 360, to the whole Circumference (now found;) ſo is the half Circumferenc of the Arch in Degrees, (found as above,) to the ſame in ſuch Meaſures as the Chord and Verſed Sine were given in.

So, things being thus far prepar'd; the Sector i meaſur'd by Prop. 4. and the Segment by the 1 Part o the Rule in this Propoſition.

Example.

Let there be the Segment of a Circle to be Meaſur'd whole Chord is 12 Inches; What is the Area of thi Segment? Anſw. 32.97 Inches. For the Radius i found (by the third part of the Rule) to be 13 Inches and the half Circumference of the Arch, (by the 4th an 5th Part of the Rule) is found to be 66.9 Inches whence (by the 4th Prop.) the Area of the Sector i 86.97 Inches, and from thence (by the 1ſt. Part of th Rule of this Prop.) the Area of the Segment is foun to be 32.97 Inches, as was ſaid above.

Note: (1) If the Verſed Sine be $\left\{\begin{matrix}\text{leſſer}\\ \text{greater}\end{matrix}\right\}$ than the Chord; then the Segment is $\left\{\begin{matrix}\text{leſſer}\\ \text{greater}\end{matrix}\right\}$ than th Semi-Circle.

(2.) If the Verſed Sine be equal to half the Chord then the Segment is juſt half the Circle; and ſo is eaſ enough meaſured.

PROP. VI.

To find the Area or Superficiality of an Ellipſis.

The RULE.

As $\left\{\begin{matrix}\text{14 to 11;}\\ \text{1.27324 to 1;}\\ \text{452 to 355;}\end{matrix}\right\}$ ſo is the Rectangle or Fa of the Tranſverſe and conjugate Diameters, to the Are of the Ellipſis; according to $\left\{\begin{matrix}\textit{Archimedes.}\\ \textit{Van Culen.}\\ \textit{Adrianus Metius.}\end{matrix}\right\}$

Example.

If the Tranſverſe Diameter of an Ellipſis be 12.5 In s, and the Conjugate Diameter be 8 Inches; What he Area of that Ellipſis? Anſ. { 78.57, 78.53, 78.54 } Inches, ording to { *Archimedes.* *Adri. Metius.* *Van Culen.* }

Anſ.		ording to
78.57	Inches.	*Archimedes.*
78.53	Inches.	*Adri. Metius.*
78.54	Inches.	*Van Culen.*

PROP. VII.

o find the Area or Superficiality of any Regular Polygon; from the Trigon to the Duodecagon.

The RULE.

Always extend the Compaſſes from 1, to the Side of given Polygon; the ſame Extent of the Compaſſes ng turn'd twice (the ſame way) from

0.433	Will reach to the Area of the	*Trigon.*
1.----		*Tetragon.*
1.7204		*Pentagon.*
2.5980		*Hexagon.*
3.6337		*Heptagon.*
4.8284		*Octagon.*
6.18183		*Nonagon.*
7.69435		*Decagon.*
9.36386		*Enodecagon.*
11.19648		*Duodecagon.*

For, As 1, is to the Square of the Side of any Regu- Polygon; ſo are the Numbers in the Table above, he Area of their reſpective Polygons.

Example.

f the Side of a Pentagon be 10; What is its Area? .172.04 For the Extent from 1, to 10, will reach ing turn'd twice the ſame way) from 1.7204, to 2.04.

PROP. VIII.

To find the Area or Superficiality of any Irregular Polygon.

The RULE.

Reduce the Irregular Polygon (by drawing Lines from Angle to Angle) either all into Triangles; or into one or more Trapezia's, and the reſt into Triangles. Then meaſure thoſe Trapezia's, or Triangles, by Prop. 1. and add them all together; ſo have you the Area of the Irregular Polygon.

Otherwiſe,

Delineate your Figure (to be meaſur'd) upon Paper; and by the ſame Scale draw alſo a Tetragon upon the ſame Paper; then cutting them out by the Lines that terminate their Figure; weigh them ſeverally in a Pair of Gold Scales. Then ſay, As the Weight of the Tetragon, is to his Area; ſo is the Weight of the Irregular Polygon, to his Area.

CHAP. IV.

Of Plano-Steriometry, or the Menſuration o the Superficiality of Solid Bodies.

SOlid Bodies (whoſe Superficies there may be occaſion to meaſure) are, either the 5 Platonic Bodies, o others; of which the former are abſolutely Regular and ſome of the others are Regular in their Kind: o which there is the Globe, the Cylinder, the Cone, th Priſm, and the Pyramid, *&c.* All which may be d chotomiz'd; and of ſome of them there are divers Kin

But the Superficiality of Solid Bodies being not ſo u ful as their Solidity, I ſhall not inſiſt ſo much upon i but ſhall only (in this place) ſhew how to find the Su ficiality of thoſe 5 Solids above-mention'd, and of t 5 Platonic Bodies.

PRO

PROP. I.

To find the Superficiality of a Globe.

The RULE.

As { 7 to 22; 1 to 3.14159; 113 to 355; } ſo is the Square of the Dia-
neter, to the Superficiality requir'd, according to
{ *Archimedes.*
Van Culen.
Adrian. Metius. }

Otherwiſe,

Always extend the Compaſſes from 1, to the Diameter of the Globe; then that Extent being turn'd
wice (the ſame way) from { 3.1428571 3.1415926 3.1415929 } will reach
the Superficiality requir'd, according to
{ *Archimedes.*
Van Culen.
Adrian. Metius. }

Example.

If the Diameter of a Globe be 10; What is its Su-
ficiality? Anſ. (according to { *Archimedes*) 314.28571
Van. Culen) 314.15926
Adr. Metius) 314.15929 }

PROP. II.

To find the Superficiality of the Segment of a Globe.

The RULE.

Firſt find the Chord of $\frac{1}{2}$ the Segment, thus: To
Square of half the Verſed Sine, add the Square of
f the Chord of the given Segment; the Square Root
the Sum, is the Chord of half the given Segment.
en,

Say, (by Duplicate Proportion Direct, *v.* Book Chap. 15. Sect. 1.) As 1, is to the Chord of half th Segment; ſo is $\left\{\begin{array}{l}3.1428571\\3.1415926\\3.1415929\end{array}\right\}$ to the Superficiality o the Convexity, (according to $\left\{\begin{array}{l}\textit{Archimedes)}\\\textit{Van Culen)}\\\textit{Adri. Metius)}\end{array}\right\}$ t which add the Superficiality of the Circular Baſe, (foun by Chap. 3. Prop. 3.) and you have the Superficialit of the whole Segment requir'd.

Example.

Let the Chord of the Segment of a Globe be 8, an its Verſed Sine 3; What is the Superficiality thereo Anſ. (according to *Metius*) 78.5398295.

PROP. III.

To find the Superficiality of a Cylinder.

The RULE.

As 1, is to the Length; ſo is the Circumference (o the Cylinder) to the Superficiality of the Convexity to which add the Area's of the Circles at each End (found by Chap. 3. Prop. 3.) and you have the Superficiality of the Cylinder requir'd.

Example. If the Length of a Cylinder be 40, and i Circumference 22; What is the Superficiality thereof? Anſ. 957.

PROP. IV.

To find the Superficiality of a Cone.

The RULE.

As 1, is to the Oblique (not Perpendicular) Altitud of the Cone; ſo is half the Circumference of the Baſe to the Superficiality of the Convexity; to which ad the Area of the Circular Baſe, (found by Chap. 3. Prop. 3. and you have the whole Superficiality of the Cone requir'd.

Example.

If the Oblique Altitude of the Cone be 50, and the ircumference of the Baſe 44; What is the Superficia- y thereof? Anſ. 1254.

PROP. V.

To find the Superficiality of the Fruſtum of a Cone.

The RULE.

As 1, is to the Oblique Altitude of the Fruſtum; ſo half the Sum of the Circumference at the Top and ottom, to the Superficiality of the Convexity; to ich add the Area of the Circular Top and Baſe, ound by Chap. 3. Prop. 3.) and you have the whole perficiality of the Fruſtum requir'd.

Example.

If the Oblique Altitude of the Fruſtum be 20, and the ircumference of the Top 22, and of the Baſe 44; hat is the Superficiality thereof? Anſ. 852.

PROP. VI.

To find the Superficiality of a Priſm.

The RULE.

The Superficiality of a Priſm, may be found in all ects like that of a Cylinder, (V. S. Prop. 3.) reſpect y being had to the Figure of its Baſes; which (whe- r they are Trigons, or Polygons, or, *&c.*) may be aſur'd, either by Prop. 1. or 6. or 7. or 8. of ap. 3.

PROP. VII.

To find the Superficiality of a Pyramid.

The RULE.

he Superficiality of a Pyramid, may be found as of a Cone (*v. s.* Prop. 4.) reſpect only being had s Baſe, which may be meaſured, either by Prop. 1. , or 7, or 8, of Chap. 3.

PROP. VIII.

To find the Superficiality of the Fruſtum of a Pyramid.

The RULE.

The Superficiality of the Fruſtum of a Pyramid, may be found as that of the Fruſtum of a Cone, (*v.* 5. Prop. 5.) reſpect had to its Baſes; which are meaſur'd as in the preceding Propoſition.

PROP. IX.

To find the Superficiality of any of the 5 Platonic Bodies.

The RULE.

Say, (by Duplicate Proportion Direct, *v.* Book 1 Chap. 15. Sect. 1.) As 1 is to the ſide of the given Platonic Body; ſo

is	1.73205	to the Superficialy of the	*Tetraëdron.*
	3 46410		*Octaëdron.*
	6.		*Hexaëdron.*
	8.66025		*Icoſaëdron.*
	20.64573		*Dodecaëdron.*

Or, As 1, is to the Square of the ſide, of any of the Platonic Bodies; ſo are the Numbers above in this Propoſition, to the Superficiality of their reſpective Platonic Body.

Example 1.

If the Side of a *Tetraëdron* be 10; What is its Superficiality? Anſw. 173.205.

Thus (kind Reader) thou haſt 828 Propoſitions fo the Menſuration of Superficies, *viz.* 815 in Chap. 3 and 13. in this.

CHAP

CHAP. V.

f Steriometry, or the Menſuration of Solids, by the Line.

THe moſt uſual Solids to be Meaſur'd, are the Quadrangular Priſm or Parallelopipedon, and the Cy- nder. I ſhall therefore begin with theſe, ſhewing ow in

PROP. I.

o find the Solidity of a Parallelopipedon (as alſo of a Cylinder;) in all the moſt uſual Meaſures, and from all the moſt uſual Data.

To avoid Tedioſity, I here exhibit a brief Table of entres or Points on the Line, by which and the follow- g Rules, all Queſtions relating to this Propoſition, may eaſily and ſpeedily reſolved.

The TABLE.

Diameter or ſide given in	Length given, in	Solidity requi'rd in	Centre for Square is at	Centre for Round is at
Any Meaſure.	the ſame	the ſame	1.	1.128
Inches	Inch.	Feet.	41.569	46.869
		Yards.	216.	243.68
	Feet	Feet.	12.	13.537
		Yards.	62.353	70.344
	Yards.	Yard.	36.	40.604
Feet	Feet.	Yards.	5 196	5.862
	Yards.	Yards.	3.	3.384

The Uſe of the Preceding Table.

(1.) When either a Square Priſm, or a Cylinder is be Meaſur'd; conſider in what Meaſures the Dimentions

tions are given, and in what Meaſures the Solidity is requir'd; and accordingly enter the Table; finding in the firſt Column the Denominative Meaſure of the given Diameter of the Cylinder, or ſide of the Parallelopipedon; and (within that Line of Connection) in the ſecond Column, find the Denominative Meaſure of the given length; and (within that Line of Connection) in the third Column, find the Denominative Meaſure of the requir'd Solidity; and againſt it in the fourth Column, (for a Parallelopipedon) or in the fifth Column, (for a Cylinder) you will find a Number, which I call the Centre; becauſe if at that Number on the Line, a Point or Centre be made, it will be of conſtant uſe, in all Queſtions of the ſame *Data* and *Quæſitum*. The Centre being thus found; this is the

General Rule.

Say, (by Duplicate Proportion Direct, *V. Book* 1. *Chap.* 15. *Sect.* 1.) As the Centre is to the given Diameter of the Cylinder, or Side of the Parallelopipedon; ſo is the length to the Solidity requir'd.

Therefore,

Always extend the Compaſſes from the Centre, to the given Diameter of the Cylinder, or ſide of the Parallelopipedon; the ſame Extent being turn'd twice (the ſame way) from the given length, will reach to the Solidity requir'd.

Example 1.

(1.) Of a Parallelopipedon to be Meaſured; whoſe given length ſuppoſe 16 Feet, and the ſide of the Square its Baſe 18 Inches, and whoſe Solidity is required in Feet.

Here, becauſe the ſide of the Parallelopipedon is given in Inches, I find Inches in the firſt Column of the Table; and (within that Line of Connection) in the ſecond Column (becauſe the length is given in Feet) I find Feet; and within that Line of Connection, in the third

hird Column (becauſe the Solidity is requir'd in Feet) I find Feet; and againſt it in the fourth Column I find 12. which is now the Centre, (and is ſo in all Queſtions of the ſame *Data* and *Quæſitum.*) Therefore, (by the General Rule above) I extend the Compaſſes from 12 (the Centre) to 18 (the ſide of the Parallelopipedon in nches,) and turning the ſame Extent of the Compaſſes twice the ſame way, from 16, (the length in Feet,) hey will reach to 36 the Solidity in Feet, requir'd.

(2.) But if the Baſe of the Parallelopipedon be (not Geometrical Square,) but an Oblong; then, the cuſtomary way, is to add together the breadth and thickneſs, nd take half their Sum for the ſide of a Mean Square; nd then to Meaſure it as in the Preceding Example. But his way (tho' generally us'd by all Timber Meaſures) falſe and very erroneous; and that more or leſs, acording to the greater or leſſer Difference of the breadth nd thickneſs.

But the true way to meaſure unequal ſided Parallelopipedons is thus; *viz.* Either (1) Divide the ſpace (on he Line) between the breadth and thickneſs, into two qual parts, and that middle Point ſhews the true ſide f a Mean Square: and then Meaſure the Parallelopipedon, as in the preceding Example. Or, (ſecondly, which will effect the ſame thing,) Extend the Compaſſes om the Centre, to the $\left\{\begin{array}{l}\text{Breadth,}\\ \text{Thickneſs,}\end{array}\right\}$ the ſame Exent will reach the ſame way from the $\left\{\begin{array}{l}\text{Thickneſs,}\\ \text{Breadth,}\end{array}\right\}$ a fourth. Then the Extent from the Centre, to that urth, will reach from the length, to the Solidity, quir'd.

Example 2.

Suppoſe a Parallelopipedon, to be Meaſur'd, was 24 nches broad, and 12 Inches thick, and 18 Feet long; d the Solidity requir'd in Feet. Here, by the Cuſtomary ay, I add 24 Inches the Breadth, to 12 Inches the hickneſs, their Sum is 36, the half whereof is 18

Inches; (which is taken to be the ſide of a Square equal to the Oblong, and the Parallelopipedon is ſupos'd to be thus reduced from an Oblong, to a ſquare Priſm) then I meaſure it as in Example 1. And find the ſolidity to be 40.5 ſolid Feet; which is 4.5 Feet more than the true ſolidity, as will appear from the true meaſuring; *viz.* thus, I divide the ſpace on the Line between 24 (the breath) and 12 (the Thickneſs) into two equal parts, and find the Compaſſes to reſt at 17 *Fere*, which is the true ſide of a ſquare equal to the Oblong Baſe of the Parallelopipedon; then I meaſure it as in Example 1 of this Propoſition, and find the Solidity to be 36 Feet. The ſame will be found, if (by the ſecond true way) I extend the Compaſſes from 12 (the Centre) to 24 (the breadth,) the ſame Extent will reach from 12 (the Thickneſs) to a fourth, which here will be 24, then the Extent from 12, (the Centre) to (this fourth, *viz.* 24) will reach from 18 (the Length in Feet,) to 36, the Solidity true in Feet, as before.

Example 3.

(3.) Of Meaſuring a Cylinder, whoſe given Diameter, ſuppoſe 18 Inches, and Length 18 Feet long; and whoſe Solidity is required in Feet. Here I find the Centre as before for the Parallelopipedon, with this difference only; that whereas then I found it in the fourth, now I find it in the fifth Column; (*v. s.* in Rule 1. of this Prop.) Thus the Centre (in this Example,) will be found to be at 13.537.

The Centre being thus found, I proceed to meaſure the Cylinder (by the General Rule above in this Prop.) and find its Solidity to be 31.83 Feet.

(4.) But, if the Baſe of the Cylinder (to be meaſured, be an Ellipſis; find a mean Proportional between the two Diameters of the Ellipſis, as you did before for the Oblong Baſe of the Parallelopipedon; *viz.* Divide the ſpace (on the Line) between the Tranſvers and conjugate Diameters (of the Ellipſis) into two equal parts. So having thus found the Diameter of a Circle equal to the

Ellipſis

llipſis, proceed to Meaſure the Cylinder, as in Example 3. Otherwiſe, extend the Compaſſes from the Centre, the $\left\{\begin{array}{l}\text{Conjugate}\\ \text{Tranſvers}\end{array}\right\}$ Diameter, the ſame Extent will ach (the ſame way) from the $\left\{\begin{array}{l}\text{Conjugate}\\ \text{Tranſvers}\end{array}\right\}$ Diame-r, to a fourth: then again, the Extent from the Centre, this fourth, will reach (the ſame way) from the ngth, to the Solidity requir'd.

Example 4.

Suppoſe an Elliptical Cylinder (for ſo I may call ſuch Figure as I have now been ſpeaking of) were to be mea-red, the Tranſverſe Diameter of its Baſe is 24 nches, and its conjugate Diameter 12 Inches, and the ngth of the Cylinder 18 Feet, and the Solidity re-uired in Feet. Here by either of the two ways (of eaſuring an Elliptical Cylinder) mention'd above, the olidity will be found to be 28.28 Feet.

Theſe Examples, I think are ſufficient to make this firſt ropoſition plain and intelligible to any (though but Ordinary) Capacity.

And thus thou haſt 20 Propoſitions in this one, *viz.* 10 r the Parallelopipedon, and 10 for the Cylinder, (and we include the Elliptical Cylinder, and unequal ſided arallelopipedon, there will be 40 Propoſitions included this one,) for though there be but 8 Centres (for each) the Table; yet the firſt Centre ſerves for 3 (or more) ifferent Caſes, *viz.* when the Data and Queſitum are ll the ſame, whither they be Inches, Feet, or Yards, r, &c.

PROP. II.

o find (in any uſual Meaſure) what length a Parallelopipe-don, or Cylinder, muſt be, to make a Solid Inch, Foot, Yard, &c. the ſide of the Parallelopipedon, or Diameter of the Cylinder being given, in any uſual Meaſure.

Here are the ſame Number of Problems as in the receding Propoſition; and all of them reſolvable from he Table there, and the following

RULES.

RULES.

Find (in the firſt Column of the Table) the Denominative Meaſure of the given ſide of the Parallelopipedon, or Diameter of the Cylinder; and (within that Line of Connection) in the ſecond Column, find the Denominative Meaſure of the required length; and (within that Line of Connection) in the third Column, find the Denomination of that ſolid Meaſure whoſe length is requir'd; and againſt it in the fourth or fifth Column reſpectively, is a Number, which I call the Tabular Number: which Number being thus found, this is the

General Rule.

Extend the Compaſſes from the given ſide of the Parallelopipedon (or Diameter of the Cylinder) to the Tabular Number; the ſame Extent being turn'd twice (the ſame way) from 1, will reach to the length ſought.

Example 1.

Let there be a Parallelopipedon, whoſe ſide is given 6 Inches, and let it be requir'd to find the length (in Feet) to make a ſolid Foot. Here entering the Table according to the Rule, I find the Tabular Number to be 19, whence (by the General Rule above) I find, that 4 Feet in length will make a ſolid Foot.

Example 2.

If (from the ſame Data) the Length had been requir'd in Inches; the Tabular Number would have been found to be 41.569, and from thence the length in Inches to make a ſolid Foot, would be found 48.

Example $\left\{\begin{matrix}3.\\4.\end{matrix}\right.$

If from the ſame Data, in a Cylinder, it be requir'd to find the length in Feet or Inches, to make a ſolid Foot, the Tabular Number; in the firſt Caſe, will be 13.537 and nd in the ſecond Caſe, 46,896, and from thence the ength in Feet will be found to be 5.0895, and in In- es, 61,089. And this is the true Length (either in eet, or Inches,) to make a Solid Foot, as was re- uir'd.

But if the Baſe of the Parallelopipedon be an Ob- ng, or of the Cylinder be an Ellipſis; Find the Side a Mean Square, for the Parallelopipedon; and Dia- eter of a Mean Circle, for the Cylinder; (by the 2d d 4th Rules of Prop. 1.) and then proceed as before.

PROP. III.

o find the Solidity of a Cylinder, the Circumference being given.

The RULE.

Find the Diameter, by Chap. 1. Prop. 3. And then oceed to meaſure the Cylinder, by Prop. 1. of this hapter. This is the *true way of Meaſuring the Cylinder*: ut,

The *cuſtomary way* is, to take a quarter of the Circum- ence, for the Side of a Square equal to the Circle; d then to meaſure it as a Parallelopipedon, by the ules in Prop. 1. of this Chapter. But this cuſtomary y always gives leſs than the Truth, by almoſt $\frac{1}{5}$ part the true content.

PROP. IV.

To find the Solidity of a Cone.

The RULE.

Firſt find the Area of its Baſe, (by Prop. 3. of Chap. 3. by Prop. 1. Note 7. of the ſame Chapter.) Then ,

As 3, is to the Area of the Baſe, (in any Meaſure); is the Perpendicular Altitude of the Cone (in the e Meaſure), to its Solidity, in the ſame Meaſure.

Example.

If the Diameter of (the Baſe of) a Cone be 10, and its Altitude 12; What is the Solidity thereof? Anſ. 314.28

Note. If the Axis or Perpendicular Altitude of a Cone, be not given; it may be found from the Oblique Altitude, thus:

From the Square of the Oblique Altitude, ſubſtract the Square of the Semidiameter of the Baſe; the Remainder is the Square of the Axis, or Perpendicular Altitude of the Cone requir'd.

PROP. V.

To find the Solidity of a compreſſed Cone.

If the Baſe of a Cone be an Elipſis; (ſuch a Figure I may call a compreſſed Cone) Find a Mean Diameter, as in Rule 4. of Prop. 1. of this Chapter; and then proceed to Meaſure the Cone by the preceding Propoſition. This needs no Example.

PROP. VI.

To find the Solidity of the Fruſtum of a Cone.

The RULE.

Firſt find the Area of the Baſes, (by Chap. 3. Prop. 1. Note 7. or by Prop. 3. of the ſame Chapter.) Then multiply the Area's of the Baſes into each other, and (by Book I. Chap. XI.) extract the Square Root of the Product: Add this Root to the Sum of the Area's of the Baſes, and multiply this laſt Sum by $\frac{1}{3}$ of the Perpendicular Altitude of the Fruſtum; the Product is the true Solidity of the Fruſtum.

Example.

Let the Diameter of the greater Baſe be 14, and of the leſſer Baſe 7, and the Perpendicular Altitude 24; What is the Solidity of the Fruſtum? Anſ. 215
For the Area of the greater Baſe is 154, and of the

leſſe

leſſer 38.5, their Product is 5929; whoſe ſquare Root is 77. Which added to 192.5 (the Sum of the Area's of the Baſes) the Sum is 269.5 Which multiply'd by 8 (⅓ of the Altitude) gives 2156, the true Solidity of the Fruſtum.

PROP. VII.

To find the Solidity of a Pyramid.

The RULE.

Conſider the Figure of its Baſe, (whether Trigon, Tetragon, Pentagon, or, *&c.*) and find the Area thereof, by Prop. 7. of Chap. 3. or by Prop. 1. Note 7. f the ſame Chapter. The Area of the Baſe being thus ound; ſay,

As 3, is to the Area of the Baſe; ſo is the Perpenicular Altitude, to the Solidity requir'd.

Example.

Let the Side of the Baſe of a Pentagonal Pyramid e 10, and its Perpendicular Altitude 30; What is the olidity of this Pyramid? Anſ. 1720.4.

PROP. VIII.

To find the Solidity of the Fruſtum of a Pyramid.

The RULE.

Have reſpect to the Figure of its Baſes, (whether rigon, Tetragon, or, *&c.*) and work in all reſpects as u did for the Fruſtum of a Cone, in Prop. 6.

PROP. IX.

To find the Solidity of a Globe.

The RULE.

Always extend the Compaſſes from 1, to the given ameter; and that Extent being turn'd three times (the ne way) from .523809 will reach to the Solidity reir'd.

Example.

Let the Diameter of a Globe (whoſe Solidity is re-quir'd) be 12. The Extent from 1 to 12, being turn'd three times (the ſame way) from .523809, will reach to 905.143, the Solidity of the Globe requir'd.

PROP. X.

To find the Solidity of the Segment of a Globe.

The RULE.

Firſt, (if it be not given) Find the Diameter of th Globe, of which the Segment to be meaſur'd is a part thus,

Say, As the Altitude of the given Segment, is to 1 ſo is the Square of the Semidiameter of the Baſe (o the given Segment) added to the Square of the Alti tude, to the Diameter of the Globe requir'd: fro which ſubtract the Altitude of the given Segment; th Remainder is the Altitude of the other Segment: O the Altitude of the other Segment may be found mor ſpeedily, thus; ſay,

As the Altitude of the given Segment, is to the Squar of the Semidiameter of its Baſe; ſo is 1, to the Alti tude of the other Segment requir'd. Which being thu found; Then,

Secondly, Say, As 1, is to the Altitude of the give Segment; ſo is Square of the Diameter of its Baſe, t a 4th. Then,

Thirdly, Say, As the Altitude of the other Segmen is to $\frac{1}{2}$ it ſelf, added to $\frac{1}{6}$ of the given Segment's A titude; ſo is the 4th (laſt found), to a 5th. Then,

Fourthly, Say, As 14, 11; ſo is the 5th (laſt found), to the Solidity of the Segment requir'd.

Example.

If the Altitude of a Segment of a Globe be 4, a the Diameter of his Baſe 12; What is the Solidi thereof? Anſ. 260.07.

PROP.

PROP. XI.

Another way to find the Solidity of the Segment of a Globe.

The RULE.

Firſt (by the firſt Part of the Rule in Prop. 10.) find the Diameter of the Globe of which the Segment to be meaſur'd is a part. Then,

Secondly, From the Diameter of the Globe, ſubtract the Fruſtum's Altitude, and to the Remainder add the Globe's Semidiameter, noting the Sum. Then,

Thirdly, ſay, As 1, is to that Sum; ſo is the Square of the Fruſtum's Altitude, to a 4th. Then,

Fourthly, ſay, As 1 is to 1.0487; ſo is the 4th (laſt found), to the Solidity of the Fruſtum or Segment requir'd.

PROP. XII.

Another more eaſy and more expeditious Way, to find the Solidity of the Segment of a Globe.

The RULE.

As 1, is to the Diameter of the Segment of a Globe; ſo is half its Altitude (twice turn'd on the Line), to its Solidity, near.

Note. This Rule is not Mathematically exact; but it is very eaſy and expeditious, and may ſerve well enough for Common Practice.

PROP. XIII.

To find the Solidity of a Priſm.

The RULE.

Conſider the Figure of its Baſe, (whether Trigon, Tetragon, Oblong, Pentagon, or, *&c.*) and find the Area thereof, by Prop. 7. of Chap. 3. or by Prop. 1. Note 1, 2, 3, 4, 5, 6, or 7 of the ſame Chapter;) Then ſay,

As 1, is to the Area of the Baſe; ſo is the Length of the Priſm, to his Solidity.

Example.

If the Side of a Pentagonal Priſm be 10, and its Length 100; What is the Solidity thereof? Anſ. 17204. For the Area of the Baſe is found (by Prop. 7. of Chap. 3.) to be 172.04. Then, As 1 : 172.04 :: 100 : 17204.

PROP. XIV.

To find the Solidity of a Spheroid.

The RULE.

As { 14, to 11;
1.27324, to 1;
452, to 355; } ſo is the Square of the Conjugate Diameter multiply'd by $\frac{2}{3}$ of the Tranſverſe Diameter, to the Solidity of the Spheroid.

Example.

If the Conjugate Diameter of a Spheroid be 14, and the Tranſverſe Diameter 24; What is the Solidity of the Spheroid? Anſ. 2464. For, As 14, 11; ſo is 196 (the Square of the Conjugate Diameter,) multiply'd by 16 ($\frac{2}{3}$ of the Tranſverſe Diameter), to 2464.

PROP. XV.

To find the Solidity of any of the 5 Platonic Bodies.

The RULE.

Always extend the Compaſſes from 1, to the Side of the given Platonic Body; the ſame Extent being turn'd three times (the ſame way)

From	will reach to the Solidity of the
0.117851,	*Tetraedron.*
0.417404,	*Octaedron.*
1.	*Hexaedron.*
2.181695.	*Icoſaedron.*
7.663119	*Dodecaedron.*

For, As 1, is to the Cube of the Side of any of the Platonic Bodies; ſo are the Numbers above in this Propoſition, to the Solidity of their reſpective Platonic Body.

Ex-

Example.

If the Side of an Octaedron be 10; What is its Solidity? Anſ. 471.404.

PROP. XVI.

An Univerſal Method, to find Centres on the Line, to meaſure any Superficial, Solid, or Concave Meaſure, by any kind of Meaſure whatſoever.

The RULE.

The Centre muſt always be at the Diameter of *that* ircle, or Side of *that* Square (in ſuch Meaſures as the iamater or Side is given in) that at one Meaſure in ength, (ſuch as the Length is given in) may make ne *ſuch* Meaſure as the content is requir'd in, whether pplicative or Receptive. So that this Propoſition is General Uſe, not only in Superficial and Solid Meare, but alſo in Gauging, and in Staticks.

This Propoſition (which to my knowledge was neer publiſh'd before,) is *that*, by which I have found any Hundreds of the Centres publiſh'd in this Book.

Thus thou haſt Rules for the Solution of 97 Propoſions in Solid Geometry: theſe ſhall ſuffice at preſent; t if this Book find Acceptance, I may hereafter *Deo Volente)* inlarge, not only on this, but ſeveral her Particulars: and publiſh ſome other things, not mmonly known to the World.

CHAP. VI.

The Application of Superficial and Solid Meaſure, to the Menſuration of Artificers Work.

THE ſeveral Artificers that Work by Meaſure, having different Methods of Meaſuring their Work; I ſhall, in this Chapter, ſpeak ſomething to each of them: ſhewing in

SECT. I.

The Method us'd by Carpenters in Meaſureng their Work.

I. In *Falling of Timber*, Carpenters commonly Wor by the *Tun* or Load, which is a Solid Meaſure, con taining 40 or 50 Solid Feet; *viz.* 40 Feet of round and 50 of hewn Timber, is call'd a Tun or Load; which Denomination it receives from the Suppoſition that 40 Feet of round, or 50 Feet hewn Timber, weigh about a Tun Weight, (*i. e.* 20 Hundred) which is commonly accounted a Cart-Load. The Tree being cu down, their cuſtom is, to gird it in the Middle o the Length, and folding the Line twice, (to take ¼ o it) they account that for the true ſide of the Squar And the Length they account from the Butt-End, u ſo far as the Tree will hold ½ a Foot Girt, (as the phraſe it,) *i. e.* the Line ½ a Foot when twice folded

The Dimenſions thus taken; the Tree is meaſur by Chap. 3. Prop 1. of this Book. So, the Centr for finding the Solidity in Feet, (the Side being given Inches, and the Length in Feet, which is the moſt uſu *Data*,) will be at 12. But if the Side of the Squar and the Length be given in other Meaſures; the Tab and Rules in the forementioned Propoſition, will gi the Centre.

If the Tree have any great Boughs which are Tim ber, as they phraſe it; (*i. e.* which will hold ½ a Fo

gi

girt) they commonly Meaſure them, and add them to the Whole. The Solidity of the Whole being thus found in Feet; divide it by 40, it brings it into Tuns.

But if you would at one Operation find the Solidity in Tuns; then, the Side being given in Inches, and the Length in Feet (which is the moſt uſual *Data*) the Centre will be at 75.89.

Note (1.) If round Timber be meaſur'd in order for Sale; they commonly (for Oak) caſt away an Inch out of the Square, for the Bark; (*i. e.* if a Tree be 10 Inches ſquare, they meaſure it as if it were but 9;) but for Aſh, Elm, and Beech, an Inch is too much. (2.) That this way, of taking ¼ of the Circumference for the true Square, always gives the Solidity leſs than the Truth, by about a fifth part; as was hinted above, in Prop. 3. of Chap. 5.

II. In hewing of Timber, Carpenters alſo work by the Tun or Load; (which, as I ſaid before, contains of round Timber 40, and of hewn Timber 50 Feet.) They having hew'd a Tree: their Cuſtom is to find the middle between the Butt-end, and ſo far up as it will hold Timber, (*i. e.* ſo far as it will hold ½ a Foot ſquare) and there to meaſure the Breadth of it, by clapping Rules (or other ſtreight things) to the Sides of the Tree, and meaſuring the Diſtance between them; and in the ſame manner, they take the Breadth the other way; which if they are unequal, they add them together, and take half their Sum, which they account the true ſide of the Square.

Having thus taken the Dimenſions; the Tree is Meaſured by Chap. 3. Prop. 1, ſo, the ſide of the Square being given in Inches, and the Length in Feet, (as they moſt commonly are) the Centre for finding the Solidity in Feet, will be at 12. But if the Dimenſions are given in other Meaſures, the Table and Rules in the forementioned Prop. will give the Centre.

If you would at one Operation find the Solidity in Tuns; the ſide being given in Inches, and the Length in Feet, (the moſt uſual Data,) the Centre muſt be at 84.85.

Note: Tho' their *Methods* of taking the Dimenſions of ſquare and round Timber are both erronious; yet Cuſtom has made them currant.

3. Carpenters Meaſure the Timber Frame (which ſome not improperly call'd the Carcaſs) of a Building, by the *Square*; which is a Superficial Meaſure of 10 Feet Square, *i. e.* 100 Superficial Feet. They alſo Meaſure by this Meaſure, the Partitioning, Timber-flooring or Joyſting, Roofing, and Boarding of Floors. Therefore, the Dimenſions, (*viz.* the length and breadth or height) of any ſuch Work being taken; it is Meaſur'd by Chap. 3. Prop. 1. So, the Length and Breadth being both given in Feet, (which is the moſt uſual Data,) the Centre for finding the Area in Squares, will be at 100. But if the Dimenſions are given in other Meaſures: the Table and Rules in the forementioned Prop. will give the Centre.

Note: (1.) In Flooring; the Well-holes for the ſtairs, and ways for the Chimneys, muſt be meaſured by themſelves, and deducted from the whole Flooring, if the Workman find Materials; or elſe there need be no deduction made; unleſs there be an amends made in the Price.

(2.) In Roofing, there is no Deduction made for the Holes, through which the Chimney-ſhafts paſs; or the Vacancies for Northern Lights, and Sky-Lights.

SECT. II.

The Method us'd by Brick-layers and Maſons, in Meaſuring their Work.

Brick-layers and Maſons being both the ſame in the Countrey, I have here joyn'd them together. Their Work is of divers kinds; as 1. Walling, 2. Healing or Tyling, 3. Plaiſtering, 4. Paving, and 5. making Chimneys: Of all which, I ſhall ſpeak in their Order. And

1. O

I. *Of Walling.*

1. Brick-layers commonly meaſure their Wall by the
erch or Rod, a Superficial Meaſure of $16\frac{1}{2}$ Feet ſquare,
r 272,25 Superficial Feet. So, if the Height and
ength of a Wall be given in Feet,) which is the
oſt uſual Data) the Centre for finding the Area in
uare Rods or Perches, will be at 272.25. But if the
imenſions be given in any other Meaſures; the Ta-
e and Rules in Chap. 3. Prop. 1. will find the Centre.
ote: In ſome places, Work-men have a Cuſtom, to
low but 16 Feet ſquare to the Rod; and then (the Di-
enſions being given in Feet) the Centre for finding the
rea in Square Rods, will be at 256.

2. Having thus found the Superficial Content of a
all in Square Rods; they next conſider the Thickneſs
their Wall; for they have a certain Standard Thick-
ſs, to which they reduce all their Walls; and this
andard is $\frac{1}{2}$ Brick thick; *i e.* the Length of one Brick
d the breadth of another: ſo that a Wall of 3 Bricks
ength) thick, of the ſame Height and Length with
other of $1\frac{1}{2}$ Brick thick; the former will contain
ice as many Square Rods as the later. Therefore,
ving found the Superfices of a Wall by the firſt Rule;
y, As 3, is to the Thickneſs of the Wall in $\frac{1}{2}$ Bricks
e. in breadths of Bricks; the breadth of a Brick be-
g always $\frac{1}{2}$ its Length) ſo is the Area before found,
the Area at their Standard Thickneſs of half a
ick.

3. Their Method of taking the Dimenſions is alſo to
known; which is thus, for a Wall round a Garden, or
e like, they commouly meaſure the length by a Line,
ing over the Buttreſſes; ſo likewiſe for the Height,
ey meaſure over all the Mouldings (preſſing the Line
o them) even to the middle of the Copeing.

Note: (1) If the Length of the Walls at the Ends
of a Garden, or Houſe, be taken on the *Outſide*
of the Garden or Houſe,) then the Length of the
Walls

Walls on the *Sides* (of the Garden or Houſe) ought to be taken on the Inſide. (2.) That when the Walls of a Houſe are meaſured; the Doors and Windows are likewiſe to be meaſnred, and deducted from the whole.

II. *Of Healing or Tyling.*

This is commonly meaſured by the Square, as Carpenters meaſure the Timber Frame of a Houſe; ſee *Sect.* 1. *Numb.* 3. of this *Chap.*) and there being no difficulty in taking the Dimenſions; I ſhall not need to ſay any more about it: only the Reader may here

Note, That in ſome places, they have a Cuſtom to be paid (over and above the plain Work) for all *Hollow Ware,* as they call Ridge Tiles, Corner Tiles, and Gutter Tiles. But herein the Cuſtoms differ; for in ſome Places they account every Lineal Foot of ſuch Work, for a Superficial Foot of Meaſure, and conſequently, for 100 Lineal Feet of ſuch Work, they reckon a Square of Healing. And in other places, they reckon a Superficial Foot of Meaſure for every ridge Tile, corner Tile or Gutter Tile; ſo that for a hundred ſuch Tiles, they reckon a Square of Healing. The Reaſon that they urge for theſe Cuſtoms, is a greater Trouble of laying thoſe Tiles, than of plain Tiles. But in theſe Caſes, they take the Dimenſions of their plain Work no farther than juſt to the Hollow Ware; or at moſt but a little way upon them, ſo far as they think the plain Tiles go.

III. *Of Plaiſtering.*

This Work is of two Kinds, *viz.* (1) Work Lathe and Plaiſtered; which ſome call *Ceiling*: (2) Plaiſterin upon Brick Work, or between the Quarters of Parti tioning; and theſe ſome call *Rendring.* All which ar meaſured by the Yard ſquare, which is 9 Superfici Feet: There is no difficulty in taking the Dimenſions which being taken in Feet, (as they moſt commonl are) the Centre for finding the Area in Yards, will b at 9. If the Dimenſions are given in any other Mea-

ſure

es, the Centre may be found, by the Table and Rules Chap. 3. Prop. 1.

Note: That in Partitioning, if the Workman find aterials; the Doors and Windows are meaſured by emſelves, and deducted from the whole, as is alſo th part (of the reſt) for the Quarters in the Rendring ork. But if the Workman do not find Materials, re is no Allowance to be made for them; the Trou- in cutting and fitting their Laths, being equivalent to void Spaces left for the Doors and Windows. Nei- r (in caſe of Workmanſhip only,) is there to be any owance made, (in Rendring,) for the Quarters, Bra- or Inter-Tyes; the Work being as much as (if not re than) if it were all plain.

IV. *Of Paving.*

There is no difficulty in taking the Dimenſions of Pa- g. It is meaſured differently according to the Cuſtom the place; in ſome places 'tis meaſured by the Square, Healing, (*V. Numb.* 2. of this *Section.*) And in ſome ces 'tis meaſured by the Foot; and then the Dimen- s being given in Feet (as they moſtly are) the Centre be at one. But in moſt places 'tis meaſured by the rd, as Plaiſtering; which ſee in Number 3. of this tion.

V. *Of making of Chimneys.*

Bricklayers commonly agree by the Hearth, for ma- g of Chimneys; and then they are nothing to our poſe: But they alſo very often work by the Rod, bout other Work; and then their Method for ta- g the Dimenſions is thus: If the Chimney ſtand ly and alone, not leaning againſt, or being in a ll, and it be wrought upright over the Mantle-Tree he next Floor; gird it about the Breſt for the gth, and take the Height of the Story for the Breadth, the Thickneſs of the Jaums for the Thickneſs: But he Chimney ſtand againſt (or in) a Wall, which is before meaſur'd with the reſt of the Building; th the Breadth of the Breaſt or Front, and the Depth o the two Jaums, is the Length; and the Height of th Story the Breadth; and the Thickneſs of the Jaums th Thickneſs. Having taken the Dimenſions, meaſure as Walling. *V.* Numb. 1. of this Section. [Note. He is nothing to be deducted for the Vacancy between th Hearth and the Mantle-Tree; becauſe of the Wyth and the Thickning for the next Hearth above.] Th for the Shaft of the Chimney, Girt it about in th ſmalleſt Part, for the Breadth; and take the Leng of the Shaft for the Length; which meaſure at a Bric thick, in conſideration of the Wyths, Pargeting, a Scaffolding.

SECT. III.

The Method us'd by Joyners, in Meaſuring their Wor

Joyners Meaſure their Work by the Yard ſquare, *(i.* 9 Superficial Feet.*)* The chief (if not the only) Wo which they do by Meaſure, is Wainſcoting, their cuſto is, to take the Dimenſions with 2 Strings; preſſing it i to the Mouldings; for they ſay, (and it is but Reaſon we ought to be paid for all where the Plain goes.

Therefore, when they would take the Dimenſions a Room they have Wainſcoted, they tack up a Line the Top of one corner of the Room; and as they carry down to the Bottom, they preſs it (with their Finger into all the Mouldings; this they account the breadth and they meaſure the Circumference of the Room for t length. Some Joyners will meaſure that alſo with a ſtrin but ſome do not. The Dimenſions being thus taken *Feet*, (as they moſt commonly are) their work is meaſu by Chap 3. Prop 1. So the Centre, for finding the A in Yards, will be at 9. But if the Dimenſions are given any other Meaſures; the Table and Rules in the foreme ſion'd Prop. will give the Centre.

Note (1.) That you muſt make deduction for all Win-ow-lights, and meaſure the Window-boards, Cheeks, d Saphetaes by themſelves.

(2) That for Window-Shutters, Cubboard-Doors, and ch like things as are wrought on both Sides, they rec-on Work and half; for indeed the Work is ½ more.

(3) That Cornices, Baſes, and Sub-Baſes, are ſometimes eaſur'd by the Foot lineal Meaſure. So alſo are Friezes, chitraves, and Chimney-Pieces meaſur'd; unleſs agreed r by the Great.

SECT. IV.

he Method us'd by Painters, in Meaſuring their Work.

Painters meaſure their Work by the Yard, like the yners, (V. S. Sect. 3.) and their Method of taking e Dimenſions of their Work, is alſo exactly the ſame d they give the ſame Reaſon for it; (for, ſay they e ought to be paid for all where the Bruſh goes :) nd therefore I ſhall not need to ſay more about it nly

Note (1.) That Painters never reckon Work and lf; but once, twice, or thrice, *&c.* done over.

(2.) That they do alſo very often Paint ſolid Bo-es; but I refer you for the Menſuration of them to hap. 4.

SECT. V.

he Method us'd by Sawyers in Meaſuring their Work.

They Meaſure their Work by the Foot ſuperficial; here is no difficulty in taking the Dimenſions; for ey reckon the Depth of the Carf, for the Breadth; d the Length, for the Length. The Dimenſions be-g taken, *viz.* the Breath in Inches, and the Length Feet, (as moſt commonly they are,) their Work is eaſur'd by Chap. 3. Prop. 1. So the Centre (in this ſe) will be at 12. But if the Dimenſions are given any other Meaſures, (which they ſeldom are) the

Table and Rules in the forementioned Propoſition wil give the Centre.

Having thus caſt up the Number of Feet in one Carf ſay, As 1, is to the Number of Carfs of the ſame Depth and Length; ſo is the Area of one Carf meaſur'd, t the Area of them all. Having thus caſt up their whol Work, in Feet; they are paid for it by the Hundred, (*i. e.* 100 Feet.) Then, to find the Price of any Number of Feet under 100; ſay, As 100, is to the Price o 100; which in the Country is commonly (for Oak from 32 *d.* to 36 *d.*) ſo is the given Number of Fee to their Price.

Note (1.) If the Carf be but 6 Inches (or, be le than 6 Inches) in Depth; they have a Cuſtom to b paid for *Carf and half*, (as they phraſe it,) that is, fo half ſo much more as it comes to by Meaſure. Th Reaſon they urge for this Cuſtom, is, their Trouble i Linding and Removing their Timbers.

(2.) For *Breaking Work*, (*i. e.* cutting a Log throug the Middle,) and *Slabing*, (*i. e.* cutting off the Outſi Pieces,) if the Carf be more than 12 or 13 Inche deep; they are paid by the Foot Lineal Meaſure, at 1 d 1½ *d.* 2 *d.* 2½ *d.* or 3 *d.* &c. the Foot.

S E C T. VI.

The Method us'd by Glaziers, in Meaſuring their Work

Glaziers meaſure their Work by the Superficial Foo as the Sawyers; (V. S. Sect. 5.) There is no Difficult in taking the Dimenſions; only it is to be noted, th they are beſt taken in Inches, both Length and Breadt (becauſe they commonly take their Dimenſions to ¼ an Inch,) and then the Centre for Meaſuring th Work, will be at 144. If the Dimenſions are give in any other Meaſures, the Table and Rules in Chap. Prop. 1. will give the Centre.

Note (1.) That Windows with Half-Rounds at t Top, are meaſur'd at their full Height, as if they we ſquare. Alſo, Oval, or Round Windows, are meaſur at the full Lengths and Breadths of their Diameters, as if they were ſquare. So alſo, Crocket-Windows in Stone-Work are meaſur'd by their full Squares. And the Reaſon they urge for all this, is, The Trouble in taking the Dimenſions, the Waſt of Glaſs in working, and the Trouble in ſetting it up, is (they ſay) more than the Glaſs is worth.

(2.) That Glaziers cut two Kinds of Diamond Quarries; one more acute than the other; the former, they call Long Quarries; and the later, Square Quarries. The acute Angle of the Square Quarries, is always 77 Degrees and 19 Minutes; and of the Long Quarries, 67 Degrees and 22 Minutes. Each of theſe are cut to different ſizes, which are denominated from their Number in a Foot, as 8 *s.* 10 *s.* 12 *s.* *&c.* that is, 8 Quarries of the Size call'd 8 *s.* make a ſuperficial Foot; and 10 Quarries of 10 *s.* make a Foot; and 12 of 12 *s.* and ſo of the reſt.

(3.) That a Perpendicular let fall, from one of the Obtuſe Angles, to the Oppoſite Side, is call'd the Range of a Quarry; and the longeſt Diagonal, is call'd the Length; and the ſhorter one, the Breadth: the Side and Area of a Quarry need no Explanation.

This being premis'd, I ſhall here add 5 Propoſitions, very uſeful for Glaziers; but before I come to their Solution, it will be neceſſary to Note,

(4.) That the Dimenſions, and Area of a 12 *s.* are as in the following

TABLE.

Square Quarries.			Long Quarries.	
Dimenſions.	Inches.		Dimenſions.	Inches.
Range	3. 43		Range	3. 34
Side	3. 51		Side	3. 61
Breadth	4. 38		Breadth	4. 00
Length	5. 47		Length	6. 00
Area	1. 00		Area	1. 00

(5.) That by *Inches* in the Area of a Quarry, are meant *Long Inches*, (ſuch as the Glaziers accompt by) *viz.* ſuch, whereof 12 make a ſuperficial Foot; each (being a Foot long, and an Inch broad;) containing 12 ſuperficial Inches.

PROP. I.

To find any of the Dimenſions of a Quarry of Glaſs, of any given Size; as ſuppoſe 8 *s.* or 10 *s.* or, *&c.*

The RULE.

Divide the Diſtance (on the Line) between 12 and the given Size, into two equal Parts; that Extent being laid the contrary way, from any of the Dimenſions of a 12 *s.* (exhibited in the Table above in Note 4.) will reach to the reſpective Dimenſion of the given Size.

Example $\left\{\begin{matrix}1.\\2.\end{matrix}\right.$

What is the Side of a $\left\{\begin{matrix}\text{Square}\\\text{Long}\end{matrix}\right\}$ Quarry of Glaſs, of the Size call'd 8 *s*? Anſ. $\left\{\begin{matrix}4.30\\4.41\end{matrix}\right\}$ Inches. For the Extent from 12, half way towards 8, will reach (the contrary way) from $\left\{\begin{matrix}3.51\\3.61\end{matrix}\right\}$ (the ſide of a $\left\{\begin{matrix}\text{Square}\\\text{Long}\end{matrix}\right\}$ 12 *s.*) to $\left\{\begin{matrix}4.30\\4.41\end{matrix}\right\}$ the Side of a $\left\{\begin{matrix}\text{Square}\\\text{Long}\end{matrix}\right\}$ 8 *s.* ſought.

By the ſame Method may any of the other Dimenſions (*viz.* the Range, Breadth, or Length) be found. So that here are 4 Propoſitions compriz'd in one.

PROP. II.

To find the Area of a Quarry of Glaſs, of any given Size.

The RULE.

Extend the Compaſſes from 12, to the given Size; that Extent will reach (the contrary way) from 1 (the Area of a 12 *s.*) to the Area of the given Size requir'd.

Example.

What is the Area of a Quarry of Glaſs, of the Size, all'd 8 *s*? Anſ. 1.5 Inch.

PROP. III.

Having any one of the Dimenſions, (*viz. Range, Side Breadth, or Length,*) *of a Quarry of Glaſs; To find the Denomination of its Size.*

The RULE.

Extend the Compaſſes from the reſpective Dimenſion f a 12 *s.* (exhibited in the Table above in Note 4.) o the Dimenſion of your given Quarry; that Extent eing turn'd twice (the contrary way) from 12, will each to the Denomination of the Size requir'd.

Example $\left\{\begin{array}{l}1.\\2.\end{array}\right.$

Of what Size is that $\left\{\begin{array}{l}\text{Square}\\\text{Long}\end{array}\right\}$ Quarry of Glaſs, hoſe Side is $\left\{\begin{array}{l}4.30\\4.41\end{array}\right\}$ Inches? Anſ. 8 *s.* For the Extent from $\left\{\begin{array}{l}3.51\\3.61\end{array}\right\}$ (the Side of a $\left\{\begin{array}{l}\text{Square}\\\text{Long}\end{array}\right\}$ 12 *s.*) o $\left\{\begin{array}{l}4.30\\4.41\end{array}\right\}$ the Side of the given $\left\{\begin{array}{l}\text{Square}\\\text{Long}\end{array}\right\}$ Quarry, ill reach (being twice turn'd) from 12 to 8.

By the ſame Method, may the ſame thing be found, om any of the other Dimenſions; *viz.* Range, Breadth, Length: So that here alſo are 4 Propoſitions compriz'd in one.

PROP. IV.

Having the Area of a Quarry of Glaſs; To find the Denomination of its Size.

The RULE.

Extend the Compaſſes from 1, (the Area of a 12 s.) to the Area of the given Quarry; that Extent ſhall reach (the contrary way) from 12; to the Denomination of the Size requir'd.

Example.

Of what Size is that $\left\{\begin{matrix}\text{Square}\\ \text{Long}\end{matrix}\right\}$ Quarry of Glaſs, whoſe Area is 1.5 Inch? Anſ. 8 s.

PROP. V.

To find whether a Window be Glazed with Square, or Long Quarries.

The RULE.

Having meaſur'd the Length and Breadth of one of the Quarries; Extend the Compaſſes from the Breadth to the Length; and if that Extent being apply'd (the ſame way) from 4, do reach to $\left\{\begin{matrix}5,\\ 6,\end{matrix}\right\}$ then are they $\left\{\begin{matrix}\text{Square}\\ \text{Long}\end{matrix}\right\}$ Quarries. This needs no Example.

SECT. VII.

The Method us'd by Surveyors in Meaſuring their Work.

The Work of Surveyors is Meaſuring and Mapping of Land; which they generally do by the Acre; a ſuperficial Meaſure, containing 160 ſquare Perches.

I ſhall not here inſiſt upon the many different Ways, which (by different Inſtrumerts) Land may be meaſur'd; but ſhall ſuppoſe the Dimenſions taken; and then let the Figure of the Field be a Circle, a Quadrangle, or what elſe ſoever; it may be meaſur'd by Chap. 3. of this Book. If the Figure of the Field be reduc'd to a Square, or Oblong, (as the Notes in Chap. 3. Prop. 1. ſuppoſe) and the Length and Breadth be given (as they often are) in Perches; the Centre (to find the Area in Acres) will be at 160. If in *Gunter*'s Chains, at 10.

But if the Dimenſions be given (as moſt uſually they are) in *Gunter*'s *Chains* and *Links*, (*i. e.* Centecimal Parts of a Chain.) The beſt and readieſt Method to find the Content, is, to make the Centre at 625, (the ſquare Links in a Perch.) And ſaying, As 625, is to one ſide of a Parallelogram, in Chains and Links; ſo is the other ſide, in Chains and Links, to the Content in Perches: Which are readily reduc'd into Acres, Roods, and Perches, by the following Table.

Note: If the Figure to be meaſur'd, be either a Trapezia, or a Triangle; (as for the moſt part it will be one of them) Then, for the Trapezia, you muſt take but ½ the Diagonal, and the whole Sum of the Perpendiculars; or ½ the later, and the whole former: And for the Triangle, take ½ the Baſe, and the whole Perpendicular; or ½ the Perpendicular, and the whole Baſe: and with theſe Numbers work as if it were a Parallelogram.

By this Method, (if the Figure to be meaſur'd be not too large) you may work almoſt as nicely as (and far more expeditiouſly than) by the Pen. I have by this Method meaſur'd a Figure of 8 Acres in Content, to the nicety of ½ a Perch.

A

A TABLE to reduce Square Perches into Acres, Roods, and Perches.

Perches.	Acres.	Roods.	Perches.	Acres.	Roods.
40	0	1	1000	6	1
80	0	2	1040	6	2
120	0	3	1080	6	3
160	1	0	1120	7	0
200	1	1	1160	7	1
240	1	2	1200	7	2
280	1	3	1240	7	3
320	2	0	1280	8	0
360	2	1	1320	8	1
400	2	2	1360	8	2
440	2	3	1400	8	3
480	3	0	1440	9	0
520	3	1	1480	9	1
560	3	2	1520	9	2
600	3	3	1560	9	3
640	4	0	1600	10	0
680	4	1	1640	10	1
720	4	2	1680	10	2
760	4	3	1720	10	3
800	5	0	1760	11	0
840	5	1	1800	11	1
880	5	2	1840	11	2
920	5	3	1880	11	3
960	6	0	1920	12	0

The Uſe of the foregoing Table.

Find, in the firſt or fourth Column, the given Number of Perches; and againſt it, in the two following Columns, you have their Value in Acres and Roods. But if you cannot find the exact Number of Perches in the Table; then find the next leſſer Number; which

Subtract from the given Number, and the Remainder ſhews the odd Perches, over and above the Acres and Roods exhibited in the Table. Thus, e. g. 360 Perches will be found to be 2 Acres, 1 Rood. And thus 460 Perches, will be found to be 2 Acres, 3 Roods, and 20 Perches.

Note: (1.) That if the Surveyor meaſure upon the Landlord's Account, in order to make a Map of it; he then takes the Dimenſions to the middle of the Hedges. But

(2.) If he meaſures for the Farmer, or Husbandman; then he takes his Dimenſions no farther than the Plow, Sickle, or Sythe, may go.

(3.) That tho' by the Laws of *England*, there ſhould be but one kind of Perch, (for meaſuring of Land) call'd the Statute Perch; yet there are ſeveral other Perches (call'd Cuſtomary Perches) made uſe of, in different Parts of Her Majeſties Dominions; the Lengths of which (with the Statute Perch) are as in the following

TABLE.

N.	Perches Names.	Length in Feet.
1	Tenant-right, or curt Meaſure	12.
2	Statute Meaſure	16½
3	*Lancaſhire*, or *Iriſh* Meaſure	21.
4	*Cheſhire* Meaſure	24.
5	*Scotch* Meaſure	18¾
6	Other Cuſtomary Perches, uſed in different Places of this Kingdom.	18.
7		20.
8		22½
9		28.

I ſhall here add two Propoſitions very neceſſary for Surveyors.

PROP.

PROP. I.

Having the Area of a Field meaſured by one kind of Perch; To find Area thereof, meaſured by another kind of Perch.

The RULE.

Extend the Compaſſes, from the Length of that Perch by which the Area was found, to the length of that Perch by which the Area is ſought; that Extent being turn'd twice (the contrary way) from the given Area, will reach to the Area ſought.

Example 1.

If the Area of a Field, meaſured by the Statute Perch, be 10 Acres; what would the Area of the ſame Field be, if it were meaſured by the Tenant-right Meaſure? Anſ. 18.906 Acres. For the Extent from 16.5 to 12. (which Numbers are found, in the Table above, in Note 4. of this Sect.) will reach (being twice turn'd) from 10 to 18.906.

Thus, by the ſame Method, you may ſolve 12, different Propoſitions, from the Table above, in Note 4. of this Section.

PROP. II.

Having the Plot of a Field, and its Area; to find by what Scale it was Ploted; i. e. by what Parts in an Inch.

Firſt, by any Scale, meaſure the Area of the Plot; then ſay, as the Area thus found, is to the true Area; ſo is the Square of the Scale you try'd by, to the Square of the Scale it was Ploted by.

Therefore,

Divide the Diſtance between the Area found by Tryal, and the true Area, into 2 equal Parts; then that extent ſhall reach (the ſame way) from the Scale you try'd by, to the Scale it was ploted by

Example.

Example.

Suppoſe the Area of Field, (as it is ſet down in the Plot,) e 4.5 Acres; which Plot being meaſured by a Scale of 2 in an Inch, the Area is found to be 2.52 Acres; what ale was the Field plotted by? Anſ. By a Scale of 16 an Inch.

SECT. VIII.

The Method uſed by Pioneers, in meaſuring their Work.

1. Pioneers, in digging of Vaults, Cellars, and the e, commonly work by the Yard Solid, *viz.* 27 Solid et. The Dimenſions being given, their Work is mea-red as a Parallelopipedon, by Chap. 5. Prop. 1. only ote, That depth in this Caſe, anſwers to thickneſs in at. So that if the breadth, depth and length, be all ven in Yards; the Centre will be at 1. And if the eadth and depth be given in Feet, and the length in rds; the Centre will be at 3. And ſo the Dimenſions ing given in other Meaſures; the Centre will be found the Table and Rules before mention'd.

2. In making Ramparts, Parapets, Moats, &c. (for Fortification of Towns;) alſo, in making new Ri-s, Banks to keep out the Sea or Rivers, &c, they mmonly work by the Floor, a ſolid Meaſure containing 4 ſolid Feet; which is 12 Cart Loads; for a Cart ad is, or ought to be a ſolid Yard, or 27 ſolid Feet; Cart ought to be 2 Foot $8\frac{1}{2}$ Inches broad at the Axle-within, 2 Foot high, and 5 Foot long. And then breadth and depth being given in Feet, and the length Yards; the Centre, for finding the ſolidity in Floors, l be at 10.392. But if the Dimenſions be all given Yards, the Centre will be at 3.464.

Theſe are all the Artificers I can think of at preſent, work by Meaſure, either by Superficial or Solid: ere are others that work by Lineal Meaſure; but e being no difficulty in meaſuring their Work; I l not need to ſay any thing of it.

CHAP. VII.

Staticks, by the Line.

STaticks is the Art of finding the Gravity or Weight of any body; and (according to the common acceptation of the Word) is properly no part of Geometry; it being uſually done by the Ballance: But the Gravity or Weight of a Body, may alſo be found from its Dimenſions; and ſo it is properly a Part of Geometry; and in this ſenſe I ſhall ſpeak of it. And becauſe ſome Authors under Staticks, comprehend the finding the Value of Body's; I ſhall do ſo too; and ſhall (therefore) diſtinguiſh this Chapter into 2 Sections, *viz.* (1.) *Barytometry*; and (2) *Timeometry.*

SECT. I.

Of Barytometry, or the finding the Gravity or Weight of any Body.

PROP. I.

To find the Gravity or Weight, of any Quantity, of any of the Solid or Liquid Bodies, mention'd in the following Table.

It would be too tedious to lay down particular Analogies, for every one of theſe things; I ſhall therefore (here) exhibit a brief Table of Centres or Points on the Line; by which, and the following Rules, the Gravity or Weight of any Body, may be obtained, with great Eaſe and Exactneſs.

The TABLE.

Names of the Solids and Liquids.	Solid Inches in 1 Pound Averd.	Centre for	
		Square is at	Round is
Gold.	1.47212	1.213	1.368
Quick-ſilver.	1.84018	1.356	1.530
Lead.	2.36943	1.539	1.736
ilver.	2.65413	1.629	1.837
Copper.	3.03329	1.741	1.964
Hammer'd Iron.	3.41056	1.846	2.083
Caſt Iron.	3.67920	1.938	2.163
Tin.	3.68036	1.919	2.164
Marble.	9.14602	3.024	3.421
Common-tone.	13.29257	3 645	4.113
Ho[illegible]y.	18.40213	4.290	4.840
alt-Water.	25.27128	5.020	5.671
Cheeſe.	27.04000	5.200	5.866
Freſh-Water, or Wine.	27.66378	5.260	5.933
Green Oak.	29.53083	5.434	6.130
Oyl.	30.66839	5.537	6.247
Dry Oak.	35.85891	5.988	6.755
Wheat.	38.63385	6.215	6.973

The uſe of the Preceding Table.

The Table is too plain to need any Deſcription: And to its uſe, obſerve the following Rules.

(1.) If the Body whoſe Gravity is requir'd, be either old, in the form of a Cylinder; or a Liquid in ſuch gur'd Veſſel; then, in the firſt Column of the Table, l the Name of the Body whoſe weight is requir'd, againſt it in the 4th Column is the Centre: which ng thus found, this is the

General Rule.

Extend the Compaſſes from the Centre, to the Di meter of the Cylinder in Inches; that extent bein turn'd twice (the ſame way) from the Length in Inche will reach to the Weight in Pounds Averdupois.

Example.

Let it be requir'd, to find the Weight of a Chee whoſe Diameter is 20 Inches, and thickneſs 4 Inche Here the Centre will be found to be at 5.866, and fro thence the weight of the Cheeſe will be found to 46.496 Pounds, *i. e.* 5 Nails, 6 Pounds and about a ha

(2.) But if the Body to be weighed, be Elliptico-Cyli drical, (*i. e.* if the Baſe of the Cylinder be an Ellipſi then reduce the Elliptical Baſe into a Circle, (by Prop. Rule 4, of Chap. 5. of this Book,) and then proce as before, otherwiſe work by the Second Part of t Rule but now Quoted; only for Solidity in *that Ca* read Gravity (in Pounds Averdupois) in *this*: obſe ving alſo, that the Dimenſions be given (all) in Inch This needs no Example.

(3.) If the Body whoſe weight is ſought, be either Solid in the Form of a Square Priſm; or a Fluid contai in ſuch a Figur'd Veſſel; then in the firſt Column of Table, find the Name of the Body, whoſe weigh requir'd, and againſt it in the third Column, is the C tre; which being found, this is the General

RULE.

Extend the Compaſſes from the Centre to the ſide Inches) of the Baſe of the Square Priſm; that Ext being turn'd twice (the ſame way) from the length Inches) will reach to the Gravity or Weight (in Pou Averd.) requir'd.

Example.

If a piece of Green-Oak, be 10 Inches Square, and o Feet (*i. e.* 120 Inches) long; what is the Gravity r Weight thereof? Anſ. 406.38 Pounds Averd. For (by obſerving the Rule) the *Centre* for Square Green Dak, is found to be at 5.434, and from thence, the veight of the piece propos'd in this Example, is found to e 406.38 Pounds Averd.

(4.) But if the Body to be weighed, be Oblongo-riſmical, [*i. e.* If the Baſe of the Priſm be an Oblong,] hen, Reduce the Oblong Baſe into a Geometrical Square, by Chap. 5. Prop. 1. Rule 2.) and then proceed as in ule 3. of this Propoſition. Otherwiſe, Work by the econd Part of Rule 2. of Prop. 1. of Chap. 5. only r Solidity *there*, read Gravity *here*.

(5.) If the Body whoſe Weight is requir'd be Po-ygonio-Priſmical, [I mean if the Baſe of the Priſm e a Regular Polygon,] then reduce the Polygonial aſe, into a Geometrical Square (by Chap. 1. Prop. 8.) nd then proceed by Rule 3 of this Propoſition.

(6.) If the Body (whoſe Gravity is ſought) be of ny other Figure (regular or irregular;) then, find the olidity thereof in Inches, by Chap. 5. and then (by the able in this Prop.) ſay, as the Number (in the ſecond olumn) againſt the Name of the Body, is to 1; ſo s the Solidity of the Body in Inches, to its Gravity or Veight in Pounds Averd.

Example.

How much will a ſolid Foot (*i. e.* 1728 Solid nches) of Green Oak, Weigh? Anſwer, 58.51 ounds Averd.

Thus (kind Reader) thou haſt 108 Propoſitions comprized in this one, *viz.* 18. for finding the

Gravity of {
Cylindrical
Elipticol-Cylindrical
Priſmatical
Oblongo-Priſmatical
Poligonio-Priſmatical
Other Figur'd
} Gold, Quick-silver, Lead, Silver, Copper, Hammer'd Iron, *&c.*

PROP. II.

To find any of the Quæſita (of the preceding Propoſition) in Pounds Troy.

The RULE.

Find (by the preceding Propoſition) the Gravity in Pounds Averd. which reduce into Pounds Troy, by Prop. 9. of this Chapter.

Otherwiſe,

Work by the Rules of the preceding Propoſition, only make uſe of the Table in this.

So here (alſo) are 108 Propoſitions, and all reſolvable from the *Table* in *this* (and the *Rules* in the preceding) Propoſition. I have ſo largely handled the preceding Propoſition, that I need not add any more in *this*, but only the

TABLE

TABLE.

Names of the Solids and Fluids.	Cubick Inches in One Pound Troy.	Centre for	
		Square is at	Round is at
Gold.	1.20996	1.100	1.240
Quick-ſilver.	1.51248	1.230	1.387
Lead.	1.94748	1.395	1.574
Silver.	2.18148	1.476	1.666
Copper.	2.49312	1.578	1.781
Hammer'd Iron.	2.80320	1.674	1.889
Caſt Iron.	3.02400	1.738	1.962
Tin.	3.02496	1.739	1.963
Marble.	7.51728	2.741	3.093
Common Stone.	10.92540	3.304	3.727
Honey.	15.12504	3.889	4.387
Salt-Water.	20.77092	4.557	5.141
Cheeſe.	22.22456	4.714	5.318
Freſh-Water, or Wine.	22.73736	4.768	5.379
Green Oak.	24.27192	4.926	5.558
Oyl.	25.20828	5.020	5.664
Dry Oak.	29.47308	5.429	6.124
Wheat.	31.89084	5.647	6.371

PROP. III.

Having any two Bodies (nam'd in the Table) both of the ſame Magnitude, together with the Weight of one of them; To find the Weight of the other.

This Propoſition may be ſolved from either of the receding Tables in this Chapter. This being premis'd, his is

The

The RULE.

As the Number (in the ſecond Column of the Table), againſt the Body whoſe Weight is ſought, is to the Number againſt the Body whoſe Weight is known; ſo is the Weight known, to the Weight ſought.

Example.

If there be a Maſs of Gold weighing 10 lb. How much will a Maſs of Silver (of the ſame Magnitude) weigh? Anſ. 5.54 lb. Averd. or 5.05 lb. Troy. For As 2.65413, to 1.47212; ſo is 10 lb. (if the Weight of th Gold were given in Averd. Weight), to 5.54 lb. th Weight of a like Maſs of Silver, in the ſame Weight And, As 2.18148, to 1.20996; ſo is 10 lb. (if the Weigh of the Gold were Troy Weight, to 5.05 lb. the Weigh of the equal Maſs of Silver, in Troy Weight.

This is plain, and needs no more Examples; an by the ſame Method may 306 Propoſitions be ſolved from each of the preceding Tables in this Chapter viz. 17 for each Body nam'd in the Table; *e. g.* B knowing the Weight of any Maſs of Gold, or Quick ſilver, or Lead, or, *&c.*) To find the Weight of a lik and equal Maſs of any of the other Bodies. So th this Propoſition contains in the whole, 612 differen Propoſitions.

PROP. IV.

Having the Magnitude in Inches) of any Body, (mention'd the following Table;) To find the Weight thereof (Pounds Averd.) in Air, Oyl, Freſh-Water, Salt-Wate Honey, or Quick-ſilver.

T

The TABLE.

The Names of the Bodies.	*Weight of a Solid Inch (in lbs. Averd.) when Weigh'd in*		
	Air.	Oyl.	Freſh-Water.
Gold.	.67929	.64669	.643I5
Quick-ſilver.	.54342	.51082	.50728
Lead.	.42204	.38944	.38590
Silver.	.37677	.34417	.34063
Copper.	.32967	.29707	.29353
Hammer'd-Iron.	.29320	.26060	.25706
Caſt-Iron.	.27182	.23922	.23568
Tin.	.27171	.23911	.23557
Marble.	.10933	.07673	.07319
Common Stone.	.07523	.04263	.03909
Honey.	.05434	.02174	.01820
Salt-Water.	.03957	.00697	.00343
Cheeſe.	.03698	.00438	.00084
Freſh-Water, or Wine.	.03614	.00354	.00000
Green Oak.	.03386	.00126	.00228
Oyl.	.03260	.00000	.00354
Dry Oak.	.02788	.00472	.00826
Wheat.	.02588	.00672	.01026

A Continuation of the preceding Table.

TA-

TABLE.

The Names of the Bodies.	*Weight of a Solid Inch (in Pounds Averd.) when Weigh'd in*		
	Salt-Water.	Honey	Quick-ſilver
Gold.	.63972	.62495	.13587
Quick-ſilver.	.50385	.48908	.00000
Lead.	.38247	.36770	.12138
Silver.	.33720	.32243	.16665
Copper.	.29010	.27533	.21375
Hammer'd Iron.	.25363	.23886	.25022
Caſt Iron.	.23225	.21748	.27160
Tin.	.23214	.21737	.27171
Marble.	.06976	.05499	.43409
Common Stone.	.03566	.02089	.46819
Honey.	.01477	.00000	.48908
Salt-Water.	.00000	.01477	.50385
Cheeſe.	.00259	.01736	.50644
Freſh-Water, or Wine.	.00343	.01820	.50728
Green Oak.	.00571	.02048	.50956
Oyl.	.00697	.02174	.51082
Dry Oak.	.01169	.02646	.51554
Wheat.	.01369	.02846	.51754

Before I lay down the Rule for Solving this Propoſition, it will be neceſſary for the Reader to

Note: (1.) That all Bodies being weighed in a Fluid, (as Oyl, or Water, or, *&c.*) are lighter (than when weighed in the Air) by a Maſs of that Fluid equal in Magnitude to the given Body. *e. g.* a ſolid Inch of Lead (which as the preceding Table ſhews, weighs in the Air .42204 of a Pound) when weigh'd in freſh Water, will be lighter, by the weight of a Solid Inch of the Fluid, (*viz.* .03614 of a Pound) ſo that it will weigh in freſh Water but .38590 of a Pound.

(2.) Tha

(2.) That a thing is ſaid to be weighed in Oyl, or
Vater, (or &c.) when the Scale containing the thing to
e weighed is put into the Fluid; the other remaining in
e Air: But before the thing to be weigh'd is put
to the Scale, the Scales muſt be made an *Equilibrium*,
y putting ſome ſmall Weights into the Scale of the Fluid.

(3.) That (in the preceding Table) in the Columns
f Oyl, freſh and ſalt Water, Honey and Quick-ſilver;
e Numbers below the Row of Cyphers, ſhew the Ne-
tive Gravity of the Body againſt which it ſtands, e. g.
the Column of freſh Water, againſt dry Oak, ſtands
00826 of a Pound; which ſhews that a ſolid Inch of
y Oak, will weigh in freſh Water .00826 of a Pound
legative; (*i. e.* .00826 of a Pound leſs than nothing)
.00826 of a Pound being added to a ſolid Inch of
y Oak, will make it equally heavy with the Water;
d ſwim level with the Surface thereof.

Theſe things being known; the Propoſition is ſolved
the following

RULE.

Say, as 1 ſolid Inch of any Body, is to its Weight
Air, Oyl, Freſh or Salt Water, Honey, or Salt Wa-
r, (which the Table plainly ſhews,) ſo is the Magni-
de (in Inches) of the given body, to its weight in the
e Fluid.

$$\textit{Examp.}\left\{\begin{matrix}1.\\2.\end{matrix}\right.$$

Let there be a Maſs of Lead, containing in Magnitude
ſolid Foot, or 1728 ſolid Inches; What is the Gravity
Weight thereof in $\left\{\begin{matrix}\text{Air}\\\text{Freſh Water?}\end{matrix}\right\}$ Anſ. it will
igh in $\left\{\begin{matrix}\text{Air } 729.28512\\\text{Freſh Water } 666.8352\end{matrix}\right\}$ Pounds. For,

$$1\left\{\begin{matrix}.42204\\.38590\end{matrix}\right\} :: 1728 : \left\{\begin{matrix}729.28512.\\666.8352.\end{matrix}\right.$$

Thus, by the ſame Method may 108 different Pro-
ſitions be ſolved, *viz.* 6 for every different kind of

Body mention'd in the Table. And the Table and Rule are ſo plain, as not to need another Example. Yet, leaſt the Reader ſhould be at a loſs, in finding the *Negative* Gravity of a Body, in a Fluid ſpecifically heavier than it ſelf; I ſhall add the following

Example 3.

Let there be a piece of dry Oak, containing in Magnitude 10 ſolid Feet, or 17280 ſolid Inches; What is the Negative Gravity thereof in freſh Water? or (which is the ſame thing) what weight will it bear before it ſink? Anſw. 142.7328 Pounds. For, as 1 : .00826 : : 17280 : 142.7328.

PROP. V.

Having the Weight of a Body in any one of theſe Fluids, viz. *Air, Oyl, freſh Water, ſalt Water, Honey, or Quickſilver; to find its weight in any of the other.*

The RULE.

As the weight of a ſolid Inch, (of the given Body) in that Fluid in which the weight is given, is to the weight thereof, in that Fluid in which the weight is requir'd, (which weights of a ſolid Inch are eaſily found in the Table in the preceding Prop.) ſo is the weight of the Body given, to its weight requir'd.

Example 2.

If there be a Maſs of Lead which weighs in the Air 100 Pound: what will the ſame Maſs weighs in Freſh Water? Here, (from the *Rule* in *this*, and the *Table* in the *Preceding* Prop.) I ſay, as .42204 : .38590 : : 100 : 91.436 the Anſwer requir'd.

Thus by the ſame Method, and Table, may 540 different Propoſitions be ſolved, *viz.* 30 for every of the different Bodies mention'd in the Table. *e. g.* Th

weigh

eight of a Body may be given in
Air
Oyl
Freſh Water
Salt Water
Honey
Quick-ſilver
and
quir'd in any other of theſe Fluids.

PROP. VI.

find the Weight (in Oyl, Freſh Water, Salt Water, or Honey,) of any quantity of Metal compounded (to any known Proportion) of any 2 of the Metals mentioned in in the preceding Table.

The RULE.

Say, as the weight (expreſt in the Table in Prop. 4.) f a ſolid Inch (of one of the Metals) in Air, is to the eight of a ſolid Inch (of the ſame Metal) in the re-ir'd Fluid; ſo is the weight (in Air) of the Quantity that Metal in the compound Maſs, to its weight in e requir'd Fluid.

By the ſame Method, find the weight (in the requir'd uid) of the other quantity of the other Metal, that mpoſes the Compound Maſs. The ſum of theſe two eights, is the weight (in the requir'd Fluid) of the ven Maſs of Compound Metal.

Example.

Suppoſe a Metal compounded of 11 Ounces o Penny Weight (Troy) of Silver, and 18 Penny eight of Copper; (which is now the Standard for r Sterling Silver Money in England; for 1 Pound of ver Money contains but 11 Ounces two Penny weight fine Silver, the other 18 Penny weight call'd the Al- being Copper.) How much will one Pound there- weigh in freſh Water? Anſ. 10 Ounces, 16 Penny ight, 16 Grains Troy. For according to the Rule, ay, (from the Table in Prop. 4.) As .37677, to

.34063, ſo is 5328 (the Grains in 11 Ounces two Penn weight of Silver) to 4816 Grains, the weight of the pu Silver in Water. Again, I ſay, as .32967, to .29353 ; ſo 432 (the Grains of Copper in one Pound of Silver Mo ney) to 384 Grains, the weight of the Copper in Wat Then 4816 Grains added to 384 Grains, makes 520 Grains, equal to 10 Ounces, 16 Penny weight, Grains.

By the ſame Method may 60 different Propoſitions Solved, *viz.* To find the weight (in Oyl, freſh Wat ſalt Water, or Honey,) of any of the 15 Compou Metals, may be made out of ſome two of theſe ſimp Metals, *viz.* Gold, Silver, Lead, Copper, Iron, Tin.

PROP. VII.

To find the Weight of any piece of Silver Money, in fr Water.

The RULE.

Say, as 5700 (the Grains in a Pound Troy,) is 5200 (the weight in Grains of one Pound of S ver Money, in freſh Water;) ſo is the weight of a piece of Silver Money, in the Air, to its weight freſh Water.

This Propoſition may be uſeful to detect Counterf Money. But ſince its weight in Air, is to be the *Dat* (or thing given,) I ſhall here Exhibit

A Table of the weight of Engliſh Silver Coines, 5 *s.* 2 *d.* the Ounce, according to the Statute.

Coines Names.	Weight in Troy.		
	d. w.	& Grains.	Grains alo
Five Shilling Piece.	19	8.52	464.52
Half a Crown.	9	16.26	232.26
Shilling.	3	20.90	92.90
Six-pence.	1	22.45	46.45
Groat.	1	6.96	30.96
Three-pence.	0	23.225	23.22
Two-pence.	0	15.48	15.48

PROP. VIII.

o find the Weight of any Piece of Gold Coin, in Freſh Water.

The RULE.

Say, as 5760, (the Grains in one Pound Troy,) is to 433 (the weight in Grains, of one Pound of Sterling old, in freſh Water;) ſo is the weight of any piece of old Coin in the Air, to its weight in freſh Water.

This Analogy ſuppoſes the Gold Coin to be alloy'd ith Silver; but if it be alloy'd with Copper, the 2d umber in the Analogy muſt be but 5426.

Example.

What will a Guinea piece weigh in freſh Water, its eight in Air being 129 Grains, and alloy'd with Silver? nſ. 121.6 Grains. For, as 5760 : 5433 :: 129 : 1.6.

The weight of a Gold Coin in the Air, being the *atum* in this Prop. I ſhall here add

A Table of the weight of ſome of the moſt uſual Gold oins, currant in *England*.

Coines Names.	Weight in (Troy)		
	d.w.&Gr.		Gr. alone.
Guinea.	5	9	129
Jacobus 22 *s.*	6	6	150
Ch. or Ja. 20 *s.*	5	18	138
French Spaniſh } Piſtol.	4	8	104

This Propoſition will alſo be very uſeful to Detect falſe unterfeit Money. For if you ſuſpect the Goodneſs any piece of Gold or Silver Money; weigh it in the , and (if holds weight, or if not,) (find by *this* or the preceding Prop.) how much it ſhould weigh i Water; and if it agree with the weight before found then is the piece of Money *Good*, (*i. e.* true Metal as i ought to be,) otherwiſe not. But tho' the Money b good, yet it may be too Light; which whether it be o not, its weight in Air will ſhew.

But for the readier detecting of Falſe and Counterfei Coines, I ſhall here add

A Table of the Weight (in freſh Water) of all th moſt uſual Gold and Silver Coynes, at this time curran in *England*.

	Coines Names.	Weight in (Troy)		
		d.w.&Gr.		Gr.alone
Gold.	Guinea.	5	1.6	121.6
	Jacobus, 22 *s.*	5	21.4	141.4
	Ch. or Ja. 20 *s.*	5	10.1	130.1
	French } Spaniſh } Piſtol.	4	2.0	98.0
Silver.	Five-Shilling Piece.	17	11.2	419.3
	Half-Crown.	8	17.6	209.6
	Shilling.	3	11.8	83.8
	Six-pence.	1	17.9	41.9
	Groat.	1	3.9	27.9
	Three-pence.	0	20.9	20.9
	Two-pence.	0	13.9	13.9

PROP. IX.

To reduce Pounds $\left\{\begin{matrix}\textit{Troy}\\ \textit{Averd.}\end{matrix}\right\}$ *into Pounds* $\left\{\begin{matrix}\textit{Averd.}\\ \textit{Troy.}\end{matrix}\right.$

This is a double Propoſition, and may be Solved by this double

Analogy.

As $\left\{\begin{matrix}73\text{to}60\\ 60\text{to}73\end{matrix}\right\}$; ſo is any Number of Pou

Tr

$\left\{\begin{array}{l}\text{Troy,}\\\text{Averd,}\end{array}\right\}$ to the Number of Pounds $\left\{\begin{array}{l}\text{Averd.}\\\text{Troy,.}\end{array}\right\}$ equal hereto.

Example $\left\{\begin{array}{l}\text{1.}\\\text{2.}\end{array}\right.$

In $\left\{\begin{array}{l}\text{146}\\\text{120}\end{array}\right\}$ Pounds $\left\{\begin{array}{l}\text{Troy}\\\text{Averd.}\end{array}\right\}$ how many Pounds $\left\{\begin{array}{l}\text{Averd.}\\\text{Troy ?}\end{array}\right\}$ Anſ. $\left\{\begin{array}{l}\text{120.}\\\text{146.}\end{array}\right.$

PROP. X.

To reduce Ounces $\left\{\begin{array}{l}\textit{Troy}\\\textit{Averd.}\end{array}\right\}$ *into Ounces* $\left\{\begin{array}{l}\textit{Averd.}\\\textit{Troy.}\end{array}\right.$

This propoſition is alſo Two-fold, and may be ſolved y this Two-fold

Analogy.

As $\left\{\begin{array}{l}\text{72 to 80}\\\text{80 to 73}\end{array}\right\}$ ſo is any Number of Ounces $\left\{\begin{array}{l}\text{Troy}\\\text{Averd.}\end{array}\right.$ the Number of Ounces $\left\{\begin{array}{l}\text{Averd.}\\\text{Troy}\end{array}\right\}$ equal thereto.

Example $\left\{\begin{array}{l}\text{1.}\\\text{2.}\end{array}\right.$

In $\left\{\begin{array}{l}\text{146}\\\text{160}\end{array}\right\}$ Ounces $\left\{\begin{array}{l}\text{Troy}\\\text{Averd.}\end{array}\right\}$ how many Ounces $\left\{\begin{array}{l}\text{Averd.}\\\text{Troy ;}\end{array}\right\}$ Anſ. $\left\{\begin{array}{l}\text{160.}\\\text{146.}\end{array}\right.$

PROP. II.

Having the $\left\{\begin{array}{l}\text{Diameter}\\\text{Side}\end{array}\right\}$ (in Inches) of a $\left\{\begin{array}{l}\text{Globe or Sphere}\\\text{Platonick Body,}\end{array}\right\}$ of any of the Mettals, or Stones, ention'd in the following Table ; to find its Gravity or eight.

Here being 16 propoſitions compriz'd in one, it would too tedious to lay down all their Analogies, Separatlys

I ſhall therefore (according to my uſual Method) exhibit a Brief Table, from which (not only) theſe 60 (but alſo many other) Propoſitions are eaſily deducible.

The TABLE.

The Names of the Metals and Stones.	The Weight (in Pounds Averdupoiz) of a Globe, whoſe Diameter is one Inch.	Tetraedr. whoſe ſide is one Inch.	Octaedr. whoſe ſide is one Inch.	Hexaedr. or Cube, whoſe ſide is one Inch.	Icoſae whoſe ſide is one Inch.	Dodecaedr whoſe ſide in one Inch.
Gold.	.35582	.08005	.32020	.67929	1.48199	5.20547
Quick-ſilver.	.28464	.06404	.25616	.54342	1.18557	4.16427
Lead.	.22107	.04950	.19805	.42204	0.92076	3.23414
Silver.	.19735	.04440	.17760	.37677	0.82200	2.88723
Copper.	.17268	.03886	.15544	.32967	0.71923	2.52630
Hammer'd Iron.	.15357	.03455	.13820	.29320	0.63967	2.24682
Caſt Iron.	.14238	.03203	.12812	.27182	0.59302	2.08298
Tin.	.14231	.03202	.12808	.27171	0.59279	2.08214
Marble.	.05726	.01288	.05152	.10933	0.23851	0.83781
Common Stone.	.03941	.00886	.03544	.07523	0.16413	0.57650
Gold.	.43291	.09740	.38960	.82647	1.80311	6.33336
Silver.	.24011	.05403	.21609	.45840	1.00009	3.51280

Becauſe Gold and Silver is commonly weighed by Troy-weight, I have therefore, (in theſe two laſt Columns,) added the Weight of each Figure of thoſe Metals) in Troy-weight.

A Deſcription of the preceding Table

May ſeem altogether Superfluous; the Table being ſo
ain of it ſelf. I ſhall therefore only ſay, that
e { 2d Column exhibits
{ 3d, 4th, &c. Columns exhibit } the Weight of
{ Globe
{ Tetraedron, Octaedron, &c. } (whoſe { Diam.
Side }
1 Inch) of Gold, Quick-ſilver, Lead, &c.

This being known, any of the *Quæſita* in this Propoſi-
on, may be eaſily found by the following

RULE.

When the Weight of { a Globe
any Platonic Body } of Gold,
, &c. is requir'd; firſt find (by the preceding Table)
e weight of { a Globe, (whoſe Diameter is one Inch
the giv. Plat. Body, whoſe ſide is 1 In. }
the given Metal, Then, the Extent of the Compaſſes
om one, to the { Diameter
Side } in Inches of the
{ Globe
Platonic Body } whoſe weight is requir'd, will reach,
ing three times turn'd (the ſame way) from the
eight found in the Table, to the weight of the Body
quir'd.

Example 1.

Suppoſe there is a Globe or Bullet of Lead, whoſe
ameter is ten Inches; What is the Weight thereof?
nſ. Firſt, I find (by the Table) the Weight of a Globe
Lead, one Inch Diameter, to be .22107 of a Pound;
d from thence I find the Weight of the given Globe
Lead to be 221.07 Pounds Averdupoiz.

Example. 2.

What will a Hexaedron (or Cube) of Gold Weight
hoſe ſide is 12 Inches? Anſw. 1173.813 Pounds
verdupoiz.

Theſe two Examples are ſufficient (I think) to ex-
ain the Rule to any ordinary Capacity. And by the
ſame

ſame Method of Working, may 60 different Propoſitions be ſolved, *viz.* To find the Weight of any Globe or Platonic Body of Gold, Quick-ſilver, Lead, Silver, or, &c.

PROP. XII.

Having the $\left\{\begin{array}{l}\textit{Diameter}\\ \textit{Side}\end{array}\right\}$ *of* $\left\{\begin{array}{l}\textit{a Globe}\\ \textit{any Platonic Body}\end{array}\right\}$ *of any of the Metals or Stones mention'd in the Table in Prop. 2. together with its weight; to find the Weight of a like and equal* $\left\{\begin{array}{l}\textit{Globe}\\ \textit{Platonic Body}\end{array}\right\}$ *of any other Metal or Stone mentioned in the Table.*

The RULE.

Say, as the weight (in the Table) of a $\left\{\begin{array}{l}\text{Globe}\\ \text{Pla. Bo.}\end{array}\right\}$ of *that* Metal whoſe weight is given, is to the weight (in the Table) of a $\left\{\begin{array}{l}\text{Globe}\\ \text{Platonic Body}\end{array}\right\}$ of *that* Metal whoſe Weight is requir'd; ſo is the weight of the $\left\{\begin{array}{l}\text{Globe}\\ \text{Platonic Body}\end{array}\right\}$ given, to the Weight of the $\left\{\begin{array}{l}\text{Globe}\\ \text{Platonic Body}\end{array}\right\}$ requir'd.

Example.

If there be a Globe or Bullet of Lead, weighin 221.07 Pounds; What will a Bullet of Silver of th ſame Diameter weigh? Anſw. 197.35 Pounds. Fo As .22107 : .19735 :: 221.07 : 197.35.

After the ſame manner, and by the ſame Table, ma 540 different Propoſitions be ſolved, *viz.* 90 for eac different Figure in the Table, *e. g.* there may be give the Diameter and Weight of a Globe of $\left\{\begin{array}{l}\text{Gold,}\\ \text{Quick-ſilv.}\\ \text{Lead, \&c.}\end{array}\right.$ to find the Weight of a Globe (of the ſame Diameter) any of the other Metals, or Stones mentioned in th

Tabl

Table; which makes 9 Propoſitions for each Metal and Stone in the Table; and they being 10 in Number, it makes 90 for each different Figure in the Table; and there being 6 of them, (*viz.* the Globe, Tetraedron, *&c.*) it makes in the Whole 540 as was ſaid before.

Thus (kind Reader) I have given thee Rules for the Solution of 2151 Problematical Propoſitions in Staticks, And many more Rules may be eaſily deduced from the Preceding Tables of this Chapter: But I had thought wholly to omit them; not only (tho chiefly) for Brevity's ſake; but alſo, becauſe they do not ſo properly belong to Staticks, eſpecially as it is here conſider'd under the Name of Barytometry. But ſince ſome good Authors, have not ſcrupl'd to admit them into the Statick Art; I ſhall here give ſome brief Hints, at the moſt uſeful of them.

I. From the 2d Column of the Table in Prop. 1. may 18 Propoſitions be deduced, *viz.* To find the Magnitude (in Solid-Inches) of any Body (mention'd in the Table) whoſe Weight is known. And this is done by this.

RULE.

Say, as 1 Pound (of any Body) is to it's Magnitude in Solid-Inches (which the Table plainly exhibits;) ſo is any other Weight of the like Body, to it's Magnitude in Inches.

$\left.\begin{array}{l}2.\\3.\end{array}\right\}$ From the $\left\{\begin{array}{l}\text{3d}\\\text{4th}\end{array}\right\}$ Column of the ſame Table, may $\left\{\begin{array}{l}36\\36\end{array}\right\}$ Propoſitions be deduc'd. *viz*, 18 for finding the $\left\{\begin{array}{l}\text{Diameter of a Cylinder}\\\text{Side of a Square Priſm}\end{array}\right\}$ of any Body (mention'd in the Table) whoſe Length and Weight is given; (and this is done by dividing the Space between the given Length and Weight, into 2 equal Parts; and applying that Diſtance the ſame way from the

Centre, it will reach to the $\left\{\begin{array}{l}\text{Diameter}\\ \text{Side}\end{array}\right\}$ ſought. And 18 for finding the Length of a $\left\{\begin{array}{l}\text{Cylinder}\\ \text{Square Priſm}\end{array}\right\}$ of any Body (mention'd in the Table) whoſe $\left\{\begin{array}{l}\text{Diameter}\\ \text{Side}\end{array}\right\}$ and Weight is given. And this is done, by extending the Compaſſes from the Centre to the given $\left\{\begin{array}{l}\text{Diameter,}\\ \text{Side,}\end{array}\right\}$ and turning that diſtance twice (the contrary way) from the given Weight, they will reach to the Length requir'd.

4. There may be a like Number of like Propoſitions, deduced from the Table in Prop. 2, when the Weight is given in Pounds Troy.

5. There may (moreover) be 305 Propoſitions deduc'd, from either of the Tables in the firſt and ſecond Prop. *viz.*

By having the Magnitude and Weight of any Body, (mention'd in the Table) to find the Magnitude of any other Body, (mention'd in the Table) of the ſame Weight.

And this is done, by ſaying, as the Number in the 2d. Column (of the Table) againſt the Body whoſe Magnitude is given, is to the Number againſt the Body, whoſe Magnitude is ſought; So is the Magnitude given, to the Magnitude ſought.

6. There may be 108 Propoſitions, deduc'd from the Table in Prop. 4*th. viz.*

To find the Magnitude (in Inches) of any Body (mention'd in the Table) whoſe Weight is given, in Air, Oyl, Freſh-water, Salt-water, Honey or Quick-ſilver.

And this is done, by ſaying, as the Weight (found in the Table) of a Cube-Inch of the given Body, is to 1; ſo is the Weight of the given Body, known, to its Magnitude (in Inches) ſought.

7. From the Table in Prop. 11. there may be 60 Propoſitions deduc'd. *viz,*

To find the $\left\{\begin{matrix}\text{Diameter of a Globe}\\ \text{Side of a Platonick-Body}\end{matrix}\right\}$ (of any of the Bodies mention'd in the Table) whoſe Weight is known, or propoſed.

And this is done, by Dividing the Diſtance between the Weight (found in the Table) of a $\left\{\begin{matrix}\text{Globe}\\ \text{PlatonickBody}\end{matrix}\right\}$ whoſe $\left\{\begin{matrix}\text{Diam.}\\ \text{Side}\end{matrix}\right\}$ is 1, and the Weight of the given $\left\{\begin{matrix}\text{Globe}\\ \text{Plantonick-Body}\end{matrix}\right\}$ into 3 equal Parts; and applying that Extent (of the Compaſſes) the ſame way from 1, it will reach to the $\left\{\begin{matrix}\text{Diameter}\\ \text{Side}\end{matrix}\right\}$ of the $\left\{\begin{matrix}\text{Globe}\\ \text{Platonick-Body}\end{matrix}\right\}$ requir'd.

8. There may alſo, be 540 other Propoſitions deduced from the Table in Prop. 11. *viz.*

By having the $\left\{\begin{matrix}\text{Diam.}\\ \text{Side}\end{matrix}\right\}$ of $\left\{\begin{matrix}\text{a Globe}\\ \text{any Platonick-Body}\end{matrix}\right\}$ of any of the Metals or Stones mention'd in the Table; together with its Weight; to find the $\left\{\begin{matrix}\text{Diameter}\\ \text{Side}\end{matrix}\right\}$ of any other $\left\{\begin{matrix}\text{Globe of the ſame Weight}\\ \text{like, and equally heavy Pla. Body}\end{matrix}\right\}$ of any of the other Metals, or Stones mention'd in the Table.

And this is done by ſaying, as the Weight (in the Table) of a $\left\{\begin{matrix}\text{Globe}\\ \text{Pla. Body}\end{matrix}\right\}$ of *that* Metal whoſe $\left\{\begin{matrix}\text{Diam.}\\ \text{Side}\end{matrix}\right\}$ is requir'd, is to the Weight (in the Table) of a $\left\{\begin{matrix}\text{Globe}\\ \text{Pla. Body}\end{matrix}\right\}$ of *that* Metal whoſe $\left\{\begin{matrix}\text{Diam.}\\ \text{Side}\end{matrix}\right\}$ is given; ſo is the $\left\{\begin{matrix}\text{Diameter}\\ \text{Side}\end{matrix}\right\}$ given, to the $\left\{\begin{matrix}\text{Diameter}\\ \text{Side}\end{matrix}\right\}$ ſought.

SECT. II.

Of Timeometry, or the Art of finding the Value or Worth of Bodies.

PROP. II.

Having the { *Diameter of a Globe* / *Side of a Platonic Body* } *of Sterling Gold, or Silver given (in Inches,) to find its Value or Worth.*

The Value (in Pounds and Decimal parts) of a

Of Sterling	Globe whoſe Diamet. is one Inch.	Tetraedron whoſe ſide is one Inch.	Octaedron whoſe ſide is one Inch.	Hexaedron or Cube whoſe ſide is one Inch.	Icoſaedron, whoſe ſide is one Inch.	Dodecaedron, whoſe ſide is one Inch.
Gold	21.1362	4.7554	19.0216	40.3512	88.0342	309.2170
Silver	.7062	.1589	.6355	1.3482	2.9414	10.3317

The Rule.

Extend the Compaſſes from 1, to the { Diam. / Side } (in Inches) of the given { Globe / Pla. Body }, the ſame Extent being turn'd three times (the ſame way) from the reſpective Value (found in the Table) of a { Globe / Plat. Body } whoſe { Diam. / Side } is one Inch; will reach to the Value of the { Globe / Plat. Body } requir'd.

Example.

What will a Hexaedron or Cube (whoſe ſide is two Inches) of Sterling Gold be worth? Anſ. 322.8096 Pounds. For, in the Table, I find the Value of a Cube (whoſe ſide is one In f Sterling Gold to be 40.3512 Pounds; whence working by the Rule) I find the Value of a Cube (of old) whoſe ſide is two Inches to be 322.8096 Pounds, at is 322 *l.* 16 *s.* 2 *d.*

By the ſame Method, and from the ſame Table, may different Propoſitions be ſolved. This (being ſo ain) needs no more Examples, only I think it not iſs, to bid the Reader

Note: (1) That by *Sterling Gold* and *Silver*, I mean ot pure Gold and Silver, but) *ſuch* Gold and Silver as r Engliſh Coines are made of, *viz.* ſuch as is alloy'd ith a certain Quantity of baſer Metal, according to Standard.

(2) The Standard for Sterling Gold, is in the Pound roy, 11 Ounces of fine Gold, and 1 Ounce of Silver, Copper, call'd the Alloy. The *Antient* Gold Coines re alloy'd with Copper, but the more *Modern* ones Guinea Pieces, *&c.*) with Silver; which is the Rea- why *thoſe* are of a red, and *theſe* of a pale Yellow. ld thus alloy'd with Silver, is by ſome Authors call'd own Gold; and now the Value of a Guinea Piece hich weighs five Penny Weight nine Grains) is by of Parliament ſettl'd at 21 *s.* 6 *d.* And on this ound, the Column for Gold, in the Preceding Table, Calculated.

3) The Standard for Sterling Silver is 11 Ounces Penny-weight Troy of fine Silver, and 18 Penny- ght of Alloy of Copper. An Ounce of ſterling Sil- is now (by the Statute) valu'd at 5 *s.* 2 *d.* And on Ground, the Column for Silver, in the preceding ble, was Calculated.

4) Our Gold Coin is of equal fineneſs with the Spa- , French, and Flemmiſh; but our Silver Coin has ſo much Alloy in it as the French or Dutch.

5) Our Engliſh Money (according to our moſt Mo- Authors) was firſt Coin'd according to the forego- Standard, (mention'd in Note 2 and 3) at a place d *Sterling*, (whence it is call'd Sterling Money,)

by *Osbright* a *Saxon* King of *Northumberland*, about 83 Years ſince. At which time one Ounce Troy of Silve was divided into 20 Pieces, and ſo eſteem'd 20 Penc that is each piece a Penny, (hence the $\frac{1}{20}$ Part of a Ounce is call'd a Penny-weight,) and ſo it continu' till King *Henry* the VIth. who valu'd the Ounce at 30 then the former Pieces or Pence went for 1½ *d.* till Kin *Edward* the IVth. when the ſame Ounce was valu'd 40 *d.* ſo that each of the aforeſaid pieces went for 2 Then King *Henry* the VIIIth. valu'd the ſame Ounce 45 *d.* and ſo it continu'd till King *Edward* the VIth. an Queen *Elizabeth*, and then the ſame Ounce was valu at 60 *d.* ſo that every Penny Weight was in Val 3.1 *d.*

(6) From what has been ſaid, it appears, that of Ste ling Gold.

			l.	*s.*	*d.*	*q.*
1	Pound	is worth	48	0	0	0
	Ounce		4	0	0	0
	Penny-weight		0	4	0	0
	Grain		0	0	2	0

And of the Sterling Silver,

1	Pound	is worth	3	2	0	0
	Ounce		0	5	2	0
	Penny-weight		0	0	3	0.
	Grain		0	0	0	0.

PROP. II.

Having the Weight (in Grains) of any Piece of Ster Gold or Silver Coin, to find its Value.

This Propoſition may be ſolved from the Table Note 6 of the preceding Propoſition; but it ma more compendiouſly done (by the Line of Numb from the following

TAB

TABLE.

Of Sterling		The Value of one Grain Weight in Decimals of a Pound, is
	Gold Coin	0.0083
	Silver Coin	0.0005

The Table needs no Explanation, but plainly exhibits e Value of one Grain of Gold or Silver Coin. herefore, to ſolve this Propoſition, this is

The RULE.

Say, as 1 Grain, is to its Value, found in the Table ; is the given weight (in Grains) of any piece or old or Silver Coin, to its Value.

Example.

What is a French Piſtol worth, it being a Gold Coin f equal fineneſs with our Sterling Gold, and) weighing 4 Grains. Anſ. 17 *s.* 3 *d.* 1 *q.* For, as 1, .0083, ſo 104 to 1632 of a Pound, that is 17 *s.* 3*d.* 1 *q.*

Note : That ſince in the two preceding Propoſitions, the lue is found in Pounds and Decimal Parts of a Pound, hall here ſhew.

A ready way to find the Value of any Decimal of a und, in Shillings, Pence, and Farthings.

The RULE.

Double the Primes, it gives Shillings ; then take the onds and thirds together as one Number, which leſſen one, it gives ſo many Farthings, to be added to the llings before found. But if the ſeconds are 5 or re, Subtract 5 from them, (and for the 5 reckon one lling,) and reckon the Remainder with the thirds as Number, and work as before. But if when the ſe- ds and thirds are taken together as one Number; y exceed not 24, they are not to be leſſen'd by one.

Thus you may eaſily find the Value of any Decimal of Pound, only by Inſpection.

Examp. { 1. 2. 3.

What is the Value of { .736 .884 .662 } of a Pound

Anſw.			
	14 *s.*	8 *d.*	3 *q.*
	17	8	1
	13	3	0

Thus much ſhall ſuffice (at this time) for the Uſe the Line of Numbers in the Staticks. I come now to

---

CHAP. VIII.

Gauging by the Line.

GAuging I define to be the Art of Meaſuring t Concavity of a Body: And it differs from Meaſ ring the Solidity of a Body only in this, that the S lidity of a Body is meaſured by ſome Applicative M ſure; as Feet, Yards or the like; but the Concavity a Body is Meaſured by ſome Receptive Meaſure; Pints, Gallons, Buſhels, or the like.

This being Premiſed; I come now to ſhew how, in

PROP. I.

To Gauge any Concave Veſſel whatſoever, by this General RULE.

When any Concave Veſſel is requir'd to be Gaug conſider the Figure of its Concavity; as whither it b Cylinder, (as in a Pail or Bucket, *&c.*) the Fruſtum Cone, (as in Tubs, Stans, *&c.*) a Parallelopidon, (a Backs, or Coolers, Ciſterns, *&c.*) or the like: and ing taken the Dimenſions in Inches; find the Conca- ity in Cube-Inches (by Chap. 5. of this Book) as if it ad been a Solid.

Having thus found the Concavity in Cube-Inches; ou may reduce it into Gallons, Barrels, or Buſhels, c. by dividing the ſame by the Number of Cube-In- es in each Meaſure, reſpectively: which Numbers are in the following

TABLE.

There is in		Cube-In	Cube-In.
A Gallon	Wine-Meaſure,	231	224
	Ale or Beer-Meaſure,	282	282
	Corn or Dry-Meaſ.	$272\frac{1}{4}$	268.8
A Barrel of	Ale	9204	9204
	Beer	10152	10152
A Buſhel, Corn-Meaſure,		2178	2150

Note 1. (1) There has been a great Controverſy about e true Number of Cube Inches in each of theſe Gal- ns; which I ſhall here endeavour to decide.

(2) The *Wine-Gallon*, is by moſt Men thought to con- in 231 Cube-Inches, yet Mr. *Mayne* believes, that if it ere carefully examined, it would be found to be con- in leſs: And Dr. *Wybard* (in his *Tactometry*) pleads rongly, that it contains but 224 or 225 Cube-Inches the moſt. This controverſy gave birth to Mr. *Wal-* 's Experiment, (in 1688) who caus'd a Brazen Veſ- l to be made, (by Mr. *Iſaac Carver*, an ingenious orkman,) in the form of a Parallelopipedon, whoſe aſe was 4 Inches, and depth 14 Inches, (as Mr *Gunton* ad done that for the Ale-Quart in the Exchequer;) by hich it was found to contain only 224 Inches, for the iquor in *this*, exactly fill'd the *Standard* in *Guild-Hall*, *ndon*, (which is unanimouſly agreed to be the true and ntient Meaſure,) in the preſence of the Right Honou- ble Sir *John Shorter* then Lord-Mayor, Sir *Baſil Fire-*

brace Sheriff, Mr. *Halley*, Mr. *Flamſtead*, and ſeveral other Learned and Worthy Gentlemen. This ſettl'd by Law, would improve the Crown Revenues ſome Thouſands *per Annum*.

(3) The *Ale-Gallon*, was antiently reckon'd to contain $288\frac{3}{4}$ Cube-Inches: But by the Care and Pains of Mr. *Nicholas Gunton*, (*v. g.* Note 2.) the juſt quantity of the Ale-Quart, (remaining in the Hands of the Chamberlaines of the Exchequer) appears to be $70\frac{1}{2}$ Cube-Inches; that is 282 in the Gallon; and ſo it is now agreed upon between the Collectors of the Exciſe and th Brewers. The Ale-Gallon in *Ireland* contains only 217.6 Cube-Inches.

(4) The *Corn-Gallon*, is by moſt Men, thought to contain $272\frac{1}{4}$ Cube-Inches; yet Mr. *Mayne* believes tha *this* Gallon (alſo) if it were carefully examin'd, i would be found to contain leſs. And the *Wincheſter-Buſhel* (which, by Act of Parliament for the Malt Tax, is eſteem'd a Legal Buſhel, according to the Standard in the Exchequer, is 18.5 Inches Diameter, and 8 Inches Deep: and conſequently the Gallon of Corn o Dry Meaſure contains but 268.8 Cube-Inches; and th Buſhel 2150 ſuch Inches.

(5) That the ſecond Column of the preceding Tabl ſhews the Number of Cube-Inches (in each reſpectiv Meaſure) according to the moſt commonly receiv'd Opinion; and as they are us'd by moſt Gaugers: But th laſt Column, ſhew the true Number of Cube-Inch in each.

(6) That the Barrel of $\left\{\begin{matrix}\text{Ale}\\ \text{Beer}\end{matrix}\right\}$ contains $\left.\begin{matrix}32\\ 36\end{matrix}\right\}$ Gallons, and ſo the Numbers in the foregoing Tab ſuppoſes it. But (by an Act of Parliament, made in th Reign of his late Majeſty, King *William* the IIId. Glorious Memory,) the Barrel of Ale and Beer (in Places out of the Liberties of *London*) are (now) to equal; and to contain each 34 Gallons; and then th Number of Cube-Inches in a Barrel will be 9588.

(7) Th

(7) That though this Rule for Gauging (laid down n this Prop.) be General, and be withal very exact; yet sit alſo very tedious. Therefore I ſhall ſhew, in

PROP. II.

A more ſpeedy way, to Gauge all kinds of Veſſels, and that in Wine, Ale, or Dry-Meaſure.

To avoid Tedioſity, I ſhall here exhibit a brief Table f Guage-Points or Centres on the Line, by which and he following Rules, the Concavity of any Veſſel, may aſily and ſpeedily be obtain'd.

The T A B L E.

The Gauge-Point, for	The Baſe of the Veſſel			
	Squa. is	Round is	Square is	Round is
Gallons of Wine	15.199	17.15	14 967	16.884
Gallons of Ale or Beer	16.792	18.95	16.792	18.95
Gallons of Corn	16.500	18.62	16.395	18.496
Corn-Buſhel.	46.668	52.66	46.368	52.310

1. This Method of Gauging by a Centre or Gauge-oint, always ſuppoſes the Veſſel (to be Gauged) to e either a Cylinder, or a Parallelopipedon whoſe Baſe a Geometrical Square: Therefore, when the Veſſel be Gauged is neither of theſe, it muſt be reduced to e of them.

(2) This being known, the Uſe of the Table is very ſy; *e. g.* If the Concavity of any Veſſel is requir'd in Vine Gallons, and the Baſe of the Veſſel be *Square*, the auge-Point is at 15.199, and if the Baſe of the Veſſel *Round*, the Gauge-Point is at 17.15 as the Table ainly exhibits. In the ſame manner, the ſecond and ird Columns of the Table, ſhews any of the other auge-Points, according to the moſt commonly receiv'd pinion of the Number of Cube-Inches in a Gallon: ut if you would Gauge truly and exactly, (according

to the Standard Meaſure:,) you muſt find the Gauge-Points in the two laſt Columns of the Table; which were Calculated from the Numbers, in the laſt Column of the Table in Prop. 1.

3, If the Veſſel to be Gauged be a *Cylinder*; (as a Pail or Bucket, or thoſe Veſſels made for Buſhels, half Buſhels, or Gallons, *&c.*) the Dimenſions being taken (as they muſt always be) in Inches; this is

The RULE.

Extend the Compaſſes from the (reſpective) Gauge-Point, to the Diameter in Inches; that Extent being turn'd twice (the ſame way) from the depth or length in Inches, will reach to the Concavity in ſuch Meaſure as your Gauge-Point was for.

Example.

Let there be a Pail or Bucket, whoſe Diameter is 10 Inches, and depth 13 Inches, and let it be requir'd to find its Concavity in Ale-Gallons. In this Caſe, I extend the Compaſſes from 18.95 (the Gauge-Point for Ale-Gallons in a round Veſſel) to 10, (the given Diameter in Inches,) and turning the ſame Extent twice (th ſame way) from 13, (the depth in Inches) it reaches to 3.64 Gallons. *i. e.* 3 Gallons and 5.15 Pints.

Note: The Decimal parts of a Gallon, are eaſily reduced into Pints, by Book 1. Chap. 4. Prop. 6.

4. If the Veſſel to be Gauged be the *Fruſtum of a Con* (ſuch are Tubs, Stans, moſt Brewers Tuns, *&c.*) muſt be reduced to a Cylinder; by finding a *Mean Diameter*, thus ——— Take the Diameter of the Veſſ at the top, and likewiſe at the bottom, add them together, and take half their Sum for a *Mean Diameter* by which Meaſure the Veſſel by the ſecond Ru foregoing.

I know, and confeſs, this Method of finding a *Me Diameter*, is not abſolutely exact; but gives the Co cavity (always ſomewhat) too little; yet it is an Appro

imati

imation near enough the Truth for common Practice. For if the greater Diameter ſhould exceed the Leſſer, by $\frac{1}{10}$ of it ſelf, (it will ſeldom do much more) yet this Method gives the *Concavity* falſe, (*viz.* too little) but the $\frac{1}{1084}$ Part of it ſelf; which is but one Pint, in 135.5 Gallons; a Matter of no Moment; for in a Veſſel of that Capacity, the irregularity of its Figure, caus'd by the ſwelling of the Wood, will produce as great an Error as that amounts to. For in *all* (eſpecially large) Veſſels made by the Cooper; the ſwelling of the Staves, makes the Circumference of the Veſſel, rather Polyhedrical than Circular; and the bottom, by ſwelling is made very extuberant and uneven, and many times, omewhat Elliptical; by reaſon it ſwells more by the Breadth of the Wood, then by the Length. And ſeeing he Circle is of all others the moſt capacious Figure; it eceſſarily follows, that all thoſe Irregularities, detract omewhat from the Natural Capacity of the Veſſel: Therefore, though the Rule laid down (above) for inding a Mean Diameter, be not the exacteſt in the Theory; yet I believe it will be often found to be ſo in ractice.

5. If the Veſſel to be Gauged be *Elliptico-priſmical*, *i. e.* f it be an Elliptical Priſm, (*viz.* the top and bottom be llipſes of equal Dimenſions;) then having taken the Tranſverſe and Conjugate Diameters, divide the Space (on the Line) between them, into two equal Parts, and he Compaſſes ſhall reſt on a Mean Diameter of a Cirle, equal to the Ellipſis; by this Mean Diameter meare the Veſſel, by the third Rule foregoing.

Or elſe Work thus:

Extend the Compaſſes from the reſpective Guage-oint to one of the Diameters of the Ellipſis, the ſame xtent being apply'd (the ſame way) from the other iameter of the Ellipſis, will reach to a fourth. Then gain, the Extent from the Gauge-Point, to this fourth ill reach (the ſame way) from the depth, to the Concavity,

cavity, in ſuch Meaſures as the Gauge-Point reſpected.

6. If the Veſſel to be Gauged be the Fruſtum of an Elliptical Pyramid; (ſuch I have ſeen ſome Keelers or Kives, and ſuch may be ſome large Tuns, for the Reaſon delivered in the fourth Rule; Having taken the Dimenſions of each Ellipſis, reduce then into Circles, as in the 5th Rule; then the Veſſel is reduced into a Cylinder, by the fourth Rule (of this Prop,) and then 'tis meaſur'd by the third Rule.

7. If the Veſſel to be Gauged be a *Cask*; as a Barrel, Hogſhead, or the like; it muſt alſo be reduced to a Cylinder, by finding a Mean-Diameter, thus ———

Conſider the Form of the Cask; and if it be a $\left\{\begin{array}{l}\text{Spheroid,}\\ \text{Paraboloid,}\\ \text{Conoid,}\end{array}\right\}$ ſay, as $\left\{\begin{array}{l}1,\ .7\\ 1,.63\\ 1,.15\end{array}\right\}$; ſo is the difference of the Diameters of the Head and Bung, to a fourth, which fourth added to the *Leſſer Diameter* (*i. e.* the Diameter of the Head) gives the *Mean Diameter*. By this *Mean Diameter*, Meaſure the Cask by the third Rule.

8. If the Veſſel to be Gauged be a *Parallelopipedon* or *Square Priſm*; (*i. e.* if the top and bottom be Geometrical Squares of equal Dimenſions) then, to Gauge it, this is the

RULE.

Extend the Compaſſes, from the reſpective Gauge-Point, to the ſide of the Square, (in Inches;) the ſame Extent of the Compaſſes, being turn'd twice (the ſame way) from the depth or length (in Inches,) will reach the Concavity, in ſuch Meaſures as your Gauge-Point was for.

Example.

Let there be a Cooler (or the like) 5 Feet (equal to 60 Inches) Square, and 10 Inches deep; what is its Concavity in Ale-Gallons? Here I extend the Compaſſes from 16.702 (the Gauge-Point for Ale-Gallons in a Square Veſſel,) to 60 (the ſide of the Square in Inches) the ſame Extent being twice turn'd (the ſame way) from 10, (the Depth in Inches) reaches to 128 Gallons, the Concavity ſought.

9. If the Veſſel to be Gauged be a Fruſtum of a Square Pyramid, it muſt be reduced to a Square-Priſm, by finding the ſide of a Mean ſquare, thus ———

Meaſure the ſides of the Square at the bottom, and likewiſe at the top, add them together, and take half their Sum for the ſide of a Mean Square; by which Meaſure the Veſſel, by the eight Rule.

I confeſs, this Rule, for finding the ſide of a mean Square, is not abſolutely exact, but is ſubject to the ſame Deficiency as that for finding a mean Diameter for the Fruſtum of a Cone; (v. Rule 4.) *viz.* a mean Square thus found, gives the Concavity too little the $\frac{1}{1084}$ part of it ſelf; which is inconſiderable, and not worth the minding; eſpecially if we conſider, how much eaſier this Method is, than the true way of Meaſuring the Fruſtum of a Pyramid.

10. If the Veſſel to be Gauged be an Oblong-Priſm, [*i.e.* if the top and bottom be Oblongs or long Squares, of equal Dimenſions] then having taken the length and breadth, in Inches, of one of the Oblongs, divide the Space on the Line betwixt them, into two equal Parts, and the Compaſſes will reſt on the ſide of a mean Square, equal to the Oblong. The Veſſel being thus reduc'd to a ſquare Priſm, meaſure it by the eight Rule foregoing.

11. But if both the top and bottom of the Veſſel to be Gauged be Oblongs, and of different Dimenſions, (ſuch a Figure I may call the Fruſtum of an Oblong Pyramid) then reduce each Oblong into a Square, by the tenth Rule; and ſo the Veſſel will be reduc'd to the Fruſtum of a Square Pyramid, and may be meaſured by the ninth Rule.

Theſe are all the uſual Figures of Veſſels to be Gauged therefore I ſhall only add a few brief Rules, to be obſerv'd ſerv'd in taking the Dimenſions, and ſo conclude this Propoſition. Therefore,

12. Firſt, becauſe the length of Casks can't eaſily be taken on the *Inſide*, it muſt be done on the outſide, remembring to deduct (from the Length ſo taken) the depth of the Chines, and the thickneſs of the Heads can't eaſily be meaſur'd, therefore know, that ———

The common ſize of the Thickneſs of the Heads of

a { Pipe, Punchion, is 1 Inch.
Hogſhead, is $\frac{3}{4}$ of an Inch.
Barrel, and other ſmaller Veſſels, about $\frac{1}{2}$ an Inch.

13. Secondly, in taking the Dimenſions of large Tuns, &c. you ought to be very nice, and take the Diameter ſeveral ways; for tho' the Veſſel were made Circular, yet they commonly become Elliptical, for the Reaſons in the fourth Rule.

14. Thirdly, in Gauging the Liquor in Brewers Tuns or Coolers, obſerve, that 'tis Cuſtomary to ſet theſe Veſſels inclining a little more towards one ſide than the other, for the Conveniency of taking out the Liquor; and therefore the beſt way in this caſe, is to pour in ſo much Water as will juſt cover the bottom of the Veſſel, meaſuring it as you pour it in; or elſe when it is in, take half the depth of it in the deepeſt place for the true depth, ſuppoſing it to cover the bottom equally and meaſure it by ſome of the preceding Rules: ſo having found the Quantity of Water poured in, alway keep it as a Reſerve; as you muſt alſo the half depth in the deepeſt place. But the former way of Meaſuring th Water poured in is the beſt; by reaſon of the Irregularity of the bottom of moſt large Veſſels, mention' in Rule 4.

Then, having alſo obſerv'd in pouring in the Wate which ſide of the Veſſel it came firſt to, and mark'd tha ſide of the Veſſel; you muſt always obſerve for the future, to take the depth of the Liquor on that ſide, an from the depth ſo taken, ſubtract your reſerved ha Depth of the Water poured in, and by the remaini epth, Gauge the Liquor, by ſome of the foregoing ules, of this Propoſition; and to the Quantity of Liuor thus found, add your Reſerve, ſo have you the ue quantity of Liquor ſought.

But if the Veſſel (that ſtands thus inclining) be the uſtum of a Cone or Pyramid; you muſt know the iameter of the Veſſel, at the Surface of the Liquor, d alſo at the Surface of the Reſerve: but theſe Diaeters muſt not be taken on the Surface of the Liquor it ſtands in the Inclining Veſſel; for that would be too ge; but they muſt be taken on the Surface of the Lior ſuppoſing it to lye Parallel with the bottom; and erefore muſt be found by Calculation, thus ——

Say, as the whole Depth of the Veſſel, is to the Difence of the Diameters at the top and bottom; ſo the reſerved Depth, to a fourth; which fourth $\left.\begin{array}{l}\text{added to}\\ \text{Subtracted from}\end{array}\right\}$ the Diameter of the bottom, if Veſſel be $\left\{\begin{array}{l}\text{bigger}\\ \text{leſſer}\end{array}\right\}$ at the top than at the bottom. es the Diameter of the Veſſel at the Surface of the erve, ſuppoſing it to lye Parallel with the bottom. is Diameter you may always keep, as being of conſtant , ſo long as the Veſſel ſtands in the ſame Poſition; therefore Note it in your Book, or mark it on the ſel.

Then, to find the Diameter on the Surface of the Lir; Firſt Meaſure the Depth thereof in the deepeſt e, and from it ſubtract the reſerved half Depth, and the Remainder, the depth of the Liquor: Alſo tract the reſerved half depth from the whole depth of Veſſel; and then ſuppoſing this remainder to be the le depth of the Veſſel; and the reſerved Diameter e the Diameter of the bottom; you may by the foreg Analogy, find the Diameter of the Veſſel, at the ace of the Liquor. Then Meaſure the Liquor by fourth or ninth Rule of this Propoſition; adding he quantity thus found your Reſerve, ſo you will have the true Quantity of Liquor in the inclining Veſſel.

PROP. III.

To find the Quantity of Liquor in any Veſſel partly full.

Reſpect being had the Figure of the Veſſel, there i no difference betwixt *this*, and the preceding Propoſition only *here* the Depth of the Liquor is taken as the dept of the Veſſel: And if the Veſſel be the Fruſtum of Cone, or Pyramid, then the Diameter of the Veſſel a the Surface of the Liquor, is taken as the Diameter o the top. And this is all the difference betwixt Gaugin a *Veſſel* to ſee how much it will hold, and Gauging th the *Liquor* in a Veſſel: except the Veſſel partly fu be a Cask: And in that Caſe Work by the fo lowing

PROP. IV.

To find the Quantity of Liquor in a Cask partly full.

To ſolve this Propoſition without a Table is a tedio piece of Work, therefore I ſhall here add

A Table of Areas of Segments.

D.	Area.	D.	Area.	D.	Area.	D.	Area.
1	.0017	26	.2066	51	.5127	76	.8155
2	.0048	27	.2178	52	.5225	77	.8263
3	.0087	28	.2292	53	.5382	78	.8369
4	.0134	29	.2407	54	.5509	79	.8473
5	.0187	30	.2523	55	.5636	80	.8576
6	.0245	31	.2640	56	.5762	81	.8677
7	.0308	32	.2759	57	.5882	82	.8776
8	.0375	33	.2878	58	.6014	83	.8873
9	.0446	34	.2998	59	.6140	84	.8967
10	.0520	35	i3119	60	.6265	85	.9059
11	.0598	36	.3241	61	.6389	86	.9149
12	.0680	37	.3364	62	.6513	87	.9236
13	.0764	38	.3487	63	.6636	88	.9320
14	.0851	39	.3611	64	.6759	89	.9402
15	.0941	40	.3735	65	.6881	90	.9480
16	.1033	41	.3860	66	.7002	91	.9554
17	.1127	42	.3986	67	.7122	92	.9625
18	.1224	43	.4112	68	.7241	93	.9692
19	.1323	44	.4238	69	.7360	94	.9755
20	.1424	45	.4364	70	.7477	95	.9813
21	.1527	46	.4491	71	.7593	96	.9866
22	.1631	47	.4618	72	.7708	97	.9913
23	.1737	48	.4745	73	.7822	98	.9952
24	.1845	49	.4873	74	.7934	99	.9983
25	1955	50	.5000	75	.8045	100	1.0000

Now to find the Quantity of Liquor in a Cask, partly l, this is

The RULE.

irst, find the whole Concavity of the Cask; (by le 7. of Prop. 2. of this Chap.) Then, putting your le in at the Bung-hole, take the Diameter there, and Note how far your Rule is wet with the Liquor, and call that the Wet Part of the Diameter; th ſay, ———

As the whole Diameter, is to the wet part therrof; is a 100 to a 4th, which being found in the precedi Table, (under D.) you will find againſt it, in the ne Column, (under Area,) a Decimal Number, which c a 5th; then ſay, as 1 is to this 5th; ſo is the wh Content of the Cask, to the Quantity of Liquor in it.

Example.

If the Diameter of a Cask at the Bung be 28 Inch the wet part of the Diameter 21 Inches, and the wh Content 60 Gallons; how much Liquor is there in t Cask? Anſw. 48.27 Gallons.

Note: This Rule ſuppoſes the Axis of the Cask to Horizontal: *i. e.* it ſuppoſes the Cask to ſtand in its tural and uſual poſture.

PROP. V.

To Gauge the Liquor in a Brewer's Copper.

To do this, you muſt firſt Gauge the *Riſing Cr* which (being the Segment of a Globe) may be d by this

RULE.

Pour in Water, till you have juſt cover'd the Riſ Crown; then take the Diameter of the Copper, at Surface of the Water; alſo take the depth of the W ter, in the deepeſt place. The Dimenſions being taken in Inches; Meaſure it as the Segment of a Gl by Chap. 5. Prop. 10 or 11 of this Book; and more peditiouſly by Prop. 12 of the ſame Chapter. The C tent being thus found in Inches; you may reduce it Gallons, by Prop. 1 of this Chapter.

Having found the Content of the Riſing-Cro keep it as a Reſerve; as you muſt alſo the depth o Water; which depth muſt always be Subtracted the depth of the Liquor, and the reſt of the Liquor e meaſured as a Cylinder, or the Fruſtum of a Cone, ccording to the Figure of the Copper; and to the Connt thereof add your Reſerve: So have you the whole Content of the Liquor; and if the Copper were full, f the whole Copper.

PROP. VI.

To Gauge a Sphere or hollow Globe.

This Propoſition is more of curioſity than any great ſe; yet it may be uſeful to find the Concavity of Gra- adoes, Bombs, or Carcaſſes. And be ſolv'd by this

RULE.

If you deſire to find the Concavity in $\left\{\begin{array}{l}\text{Wine}\\ \text{Ale}\\ \text{Corn}\end{array}\right\}$ Gal- ons; always extend the Compaſſes from $\left\{\begin{array}{l}7.69\\ 8.13\\ 8.04\end{array}\right\}$ to he given Diameter in Inches, and that turn'd 3 times the ſame way) from one, will reach the Concavity in $\left\{\begin{array}{l}\text{Wine}\\ \text{Ale}\\ \text{Corn}\end{array}\right\}$ Gallons, requir'd.

Examp. $\left\{\begin{array}{l}1.\\ 2.\\ 3.\end{array}\right.$

If the Diameter of a Sphere be 10 Inches; what is s Concavity in $\left\{\begin{array}{l}\text{Wine}\\ \text{Ale}\\ \text{Corn}\end{array}\right\}$ Gallons? Anſw. $\left\{\begin{array}{l}2.267\\ 1.699\\ 1.923\end{array}\right\}$ Gallons.

PROP. VII.

o reduce any Number of Gallons of one kind of Meaſure, into Gallons of another kind of Meaſure.

To ſolve this Sextuple Propoſition, take the three ir'd Numbers in the following

TABLE.

	Wine	Ale	Corn
Fixed Numbers for	308	376	363

This being known; if you have any Number of Gallons of one kind, which you would reduce to Gallons of another kind of Meaſure, this is

The RULE.

Say, as the Number (in the Table) under that kind of Gallon *to which* you would reduce your given Gallons, is to the Number (in the Table) under that kind of Gallon *from which* you would reduce them; ſo is your given Number of Gallons, to the Number of Gallons ſought.

Example.

Let it be requir'd to reduce 616 Gallons of Ale Meaſure, into Gallons of Wine Meaſure. To do which, I ſay, as 308 : 376 :: 616 : 752, the Number of Wine Gallons, equal to 616 Ale Gallons.

I had thought here to put an end to Gauging; but in purſuance to the late Act of Parliament, I ſhall add

PROP. VIII.

To Gauge a Heap of Corn.

For the more eaſy ſolving this Propoſition, it will be convenient to fling up the Corn into a round or ſquare heap, in the middle of the room; and taking it level on the top, it will be reduced to the Fruſtum either of a Cone, or ſquare Pyramid, and ſo may be meaſured by the 4th or 9th Rule of the ſecond Propoſition of this Chapter.

Or you may fling the Corn up againſt one Corner of the Room; but that will reduce it into a Triangular Figure, and therefore more difficult to meaſure, than the Fruſtum of a Cone, or Pyramid: ſo I think the former way the beſt.

BOOK

BOOK III.

Of the Uſe of the Line of Numbers, in Trigonometry.

PROEME.

. UNder the general Title of Trigonometry, I ſhall in this Book (beſides Trigonometry properly ſo all'd) comprehend (alſo) Aſtronomy, Geography, Navigation and Dialing; becauſe what I ſhall hear ach of theſe Sciences, is perform'd Trigonometrically.

2. In ſpeaking of Trigonometry, properly ſo call'd, I hall firſt diſcourſe of it in General; ſhewing how (withut Tables) to find the Sine, Tangent, Secant, Chord, erſed-Line, &c. of any given Arch, or Angle, anſweng to any given Sine, Tangent, &c. And conſequently, ſhall ſhew how to perform the whole Doctrine of Trionometry (as comprehending Aſtronomy, Geography, c.) without Tables, by the Line of Numbers only. nd this Diſcourſe is altogether new, being wholly my wn. Then (proceed in the ſecond place) to ſpeak ore particularly of all the ſeveral caſes of Plain and pherical Trigonometry, both Right-Angl'd and blique.

3. In treating of Aſtronomy, I ſhall ſhew how to d the Riſing, Southing, Setting, Declination, Longide, Latitude, Amplitude, Altitude, Azimuth, Right Oblique Aſcenſion and Deſcenſion, &c. of the Plats and fixed Stars. And alſo, ſeveral ways of finding time of the Day and Night by them.

4. In Geography, I ſhall ſhew how to find the Bear-

ing and Diſtance of any two places, whoſe Longitud and Latitude is known, &c.

5. In Navigation, I ſhall ſhew how to ſolve all th uſual Propoſitions concerning Longitude, Latitude Rumb, and Diſtance, &c. And ——

6. In Dialling, I ſhall ſhew how to find all the Re quiſites belonging to a Sun-Dial; as the Hour Diſtance Stile's hight, Diſtance of the Subſtile from the Me ridian, &c.

CHAP. I.

Of Trigonometry.

BEfore I proceed to the Solution of particular Propo tions, I ſhall explain ſome Symbolical Chara which for Brevity I ſhall make uſe of, in the followi Diſcourſe: And they are theſe ——

R. Radius.
S. Sine.
T. Tangent.
Se. Secant.
V-S. Verſed-Sine.
Co-S. Co-Sine.
Co-T. Co-Tangent.

B. Baſe.
P. Perpendicular.
L. (*Latus* or) Side.
Ls. Sides.
Z. Sum.
X. Difference.
A. an Angle.

PROP. I.

To find the Sine of any Arch, or Angle.

To ſolve this Propoſition, your Analogy muſt according to the Quantity of your given Arch or gle. For, if the Quantity of your given Arc Angle be

Degrees	you muſt ſay, as
1	57.1
2	57.2
3	57.3
&c.	&c.
10	58.
11	58.1
12	58.2
&c.	&c.
20	59.
21	59.1
22	59.2
&c.	&c.
30	60.
31	60.1
32	60.2
&c.	&c.
40	61.
41	61.1
42	61.2
&c.	&c.

is o the Quantity of the given Arch or Angle (if leſs han 45 Degrees,) or to its Complement to 90 (if greater;) ſo is Radius (which you may ſuppoſe 100, 1000 or 0000, as you pleaſe,) to the Sine of the given Arch r Angle, (if leſs than 45 Degrees,) or to its Co-Sine, f greater. (So if the given Arch or Angle be greater han 45 Degrees; having thus found its Co Sine, you ay find its Sine by Prop 2.)

Example.

If the given Arch or Angle be 30 Degrees; What is e Sine thereof? (Suppoſing the *R.* to be 1000) Anſw. 00. For, as 60 : 30 : : 1000 : 500.

Thus you ſee, (if you mind the preceding Table) that ho' the Analogies vary, yet they are eaſily remembred.

Note: I do not pretend that this Rule is *always* abſo-utely exact; (tho' *ſometimes* it be,) yet 'tis an Approximation near enough the Truth for common Practice.

I

I know indeed by Experience) that in Calculating Eclipſes, *&c.* the Sines and Tangents muſt be found to a greate Nicety, than can (always) be done by this Rule: Bu I know alſo, that they cannot be otherwiſe found, without many tedious Operations in Arithmetic: And thi Rule will *ſometimes* give the exact Sine; and I think i will never give it falſe above the $\frac{1}{100}$ part of the Radius a Matter of little or no Moment in common Practice.

PROP. II.

To find the Sine of any Arch or Angle; knowing the Co-Sine thereof.

The RULE.

From the ſquare of the *R.* ſubtract the ſquare of th *Co-S.* the Remainder is the ſquare of the Sine: There fore, extract the ſquare Root of the Remainder, an you have what you want.

Example.

If the *S.* of 30 Degrees be 500, what is the *S.* of 6 Degrees? Anſ. 866.

PROP. III.

To find the Co-Sine of any Arch or Angle.

The RULE.

If the given Arch or Angle be greater than 45 Degrees, its *Co-S.* is readily found by Prop. 1. But if be leſs; then find its *S.* by that Prop. Then ſubtra the ſquare of the *S.* (thus found) from the ſquare of th *R.* and the ſquare Root of the Remainder is the *Co-* ſought.

Example.

What is the Co-Sine of 60 Degrees? Anſw. (Su poſing the *R.* 1000) 500.

PRO

PROP. IV.

To find the Tangent of any Arch or Angle.

The RULE.

Firſt find the Sine of the given Arch, or Angle, by Prop. 1. and the Co-Sine by Prop. 3. Then ſay, as the *Co-S* : *S* : : R : Tangent. This needs no Example.

PROP. V.

To find the Co-Tangent of any Arch or Angle.

The RULE.

Firſt find the Sine of the given Arch or Angle, by rop. 1. and the Co-Sine by Prop. 3. Then ſay, as the : *Co-S* : : *R* : *Co-T*.

PROP. VI.

To find the Secant of any Arch, or Angle.

The RULE.

Firſt find the Co-Sine, by Prop. 3. Then ſay, as he *Co-S* : R : : R : *Secant*.

PROP. VII.

To find the Co-Secant of any Arch or Angle.

The RULE.

Firſt find the Sine by Prop. 1. Then ſay, as the *S* : :: *R*: Co-Secant.

PROP. VIII.

To find the Verſed-Sine of any Arch or Angle.

The RULE.

Firſt find the Co-Sine, by Prop. 3. Then the Ex- ſof the Radius above the *Co-S* is equal to the Ver- Sine.

PROP.

PROP. IX.

To find the Co-Verſed-Sine of any Arch or Angle.

The RULE.

Firſt find the Sine, by Prop. 1. Then the Exceſs of the Radius above the *S.* is equal to the Co-verſed-Sine.

PROP. X.

To find the Chord of any Arch or Angle.

The RULE.

Firſt find the Sine, by Prop. 1. and the *V-S.* by Prop. 8. Then the ſquare of the *S.* added to the ſquare of the *V-S.* is equal to the ſquare of the Chord.

Otherwiſe,

Take half the given Arch or Angle, and find the S thereof, by Prop. 1. double the Sine thus found, it gives you the Chord ſought. This laſt is much the eaſieſt and ſpeedieſt way of ſolving this Propoſition.

PROP. XI.

To find the Co-Cord of any Arch or Angle.

The RULE.

Firſt, find the *Co-S.* by Prop. 3. and the *Co-V-S.* by Prop. 9. Then the ſquare of the *Co-S.* added to the ſquare of the *Co-V-S.* is equal to the Square of the Co Chord.

Otherwiſe,

Take the Complement of the given Arch or Angl to 90, and find the Sine of half thereof, by Prop. Double the Sine thus found, and you have the Co-Chor requir'd.

PROP. XII.

The Radius and Sine of an Arch or Angle being given; find the Arch or Angle.

Th

The RULE.

Firſt find the *Co-S.* by Prop. 3. Then conſider hich is the greateſt, the *S.* or the *Co-S.* For if the *S.* be e $\left\{\begin{matrix}\text{Greater,}\\ \text{Leſſer,}\end{matrix}\right\}$ then the Arch or Angle ſought is $\left.\begin{matrix}\text{Greater}\\ \text{Leſſer}\end{matrix}\right\}$ than 45 Degrees. Then if the $\left\{\begin{matrix}\textit{S.}\\ \textit{Co-S.}\end{matrix}\right\}$ the greater, ſay, as R. added to half the $\left\{\begin{matrix}\textit{S.}\\ \textit{Co-S.}\end{matrix}\right\}$ o the $\left\{\begin{matrix}\textit{Co-S.}\\ \textit{S.}\end{matrix}\right\}$, ſo is 86, to the $\left\{\begin{matrix}\text{Comp. of the }\angle\text{ ſou.}\\ \text{Arch or }\angle\text{ ſought.}\end{matrix}\right.$

Example.

f the R. be 1000, and the Sine be 342. What is the h or Angle? Anſw. 20 Degrees.

PROP. XIII.

Radius and Co-Sine of an Arch or Angle being given; o find the Arch or Angle.

The RULE.

irſt find the Sine by Prop. 2. Then find (by Prop.) the Arch, or Angle anſwering to that Sine; and ſo have what you want. This needs no Example.

PROP. XIV.

Radius and Tangent of an Arch, or Angle being given; o find the Arch, or Angle.

The RULE.

irſt find two Numbers, the *Z.* of whoſe Squares is l to the Square of the *R*, and whoſe Proportion to other, is as the *R.* to the given *T*; which two Num- are found thus: —— Say, as the *Z.* of the ſquares e Ratio's, is to the *Z.* of the ſquares of the Num- (equal to the ſquare of the *R.*); ſo is the ſquare of $\left\{\begin{matrix}\text{Greater}\\ \text{Leſſer}\end{matrix}\right\}$ Ratio, to the ſquare of the

$\left\{\begin{matrix}\text{Greater}\\ \text{Leſſer}\end{matrix}\right\}$ Number. Which two Numbers are t
Sine, and Co-Sine.

Or,

(Which is the ſame thing) ſay, as the ſquare of t
R. added to the ſquare of the given *T.* is to the ſquare
the *R.* ſo is the ſquare of the $\left\{\begin{matrix}\text{Radius}\\ \text{given } T.\end{matrix}\right\}$, to the ſqua
of the $\left\{\begin{matrix}S.\text{ or }Co\text{-}S.\\ Co\text{-}S.\text{ or }S.\end{matrix}\right\}$, Having thus found the *S.* a
Co-S. Find the Arch or Angle, by Prop. 12.

Or more briefly thus:

Firſt find the Secant, thus; To the ſquare of th
add the ſquare of the *T.* the ſquare Root of the S
is the Secant. Then (if the given *T.* be $\left\{\begin{matrix}\text{Leſs}\\ \text{Greater}\end{matrix}\right\}$ t
the R.) ſay, as the *Sec.* added to ½ the $\left\{\begin{matrix}R.\\ T.\end{matrix}\right\}$, is to
$\left\{\begin{matrix}T.\\ R.\end{matrix}\right\}$; ſo is 86, to the $\left\{\begin{matrix}\text{Arch or Angle, ſought.}\\ \text{Compl. of the Arch or } \angle.\end{matrix}\right\}$

PROP. XV.

The Radius and Co-Tangent of an Arch or Angle, bein
ven; To find the Arch or Angle.

The RULE.

Firſt find the *T.* thus; ſay, as the *Co-T*: *R*::*R*:*T*;
find the Arch or Angle, by Prop. 14.

PROP. XVI.

The Radius and Secant of an Arch or Angle being g
To find the Arch, or Angle.

The RULE.

Firſt find the *Co-S.* thus; ſay, as the *Se*: *R*::*R*
Then find the Arch, or Angle, by Prop. 13.

Otherwiſe.

Firſt find the *T.* thus ; from the ſquare of the *Se.* Subct the Square of the *R.* the Square Root of the Reainder is the *T.* Then find the Arch or Angle by op. 14.

PROP. XVII.

e Radius and Co-Secant of an Arch or Angle being given ; To find the Arch or Angle.

The RULE.

Firſt find the Sine, thus ; ſay, as the *Co-Se* : *R* :: *R* : *S.* hen find the Arch or Angle, by Prop. 12.

PROP. XVIII.

e Radius and Verſed-Sine of an Arch or Angle being given ; To find the Arch or Angle.

The RULE.

Firſt find the Co-Sine, thus ; Subtract the *V-S* from e R. the Remainder is the *Co-S.* Then find the Arch or gle by Prop. 13.

PROP. XIX.

e Radius and Co-Verſed-Sine of an Arch or Angle being given ; To find the Arch or Angle.

The RULE.

Firſt find the Sine, thus ; Subtract the *Co-V-S.* from R. the Remainder is the *S.* Then find the Arch or gle, by Prop. 12.

PROP. XX.

Radius and Chord of an Arch or Angle being given ; o find the Arch or Angle.

The RULE.

irſt find the Sine of half the Arch, or Angle, s ; Half the Chord is the Sine. Then find the Arch or Angle by Prop. 12. Double the Arch or Angle th found, and you have the Arch or Angle ſought.

PROP. XXI.

The Radius and Co-Chord of an Arch or Angle being give To find the Arch or Angle.

The RULE,

Find the Arch or Angle by Prop. 20. Then ta its Complement to 90 Degrees, and you have wh you ſought.

PROP. XXII.

To ſolve any Queſtion in Trigonometry, Plain, or Spheri (or in Aſtronomy, Geography, Navigation, and Diali without the help of Tables of Sines, Tangents, Secants, &c

The RULE.

Knowing the Analogy by which the Queſtion is to wrought. Firſt aſſume the *R.* to be 1, 10, 100, or 10 &c. Then find the Sines, or Tangents, &c. (of the grees that come in Queſtion) by ſome of the firſt cedent Propoſitions, for that Purpoſe: Then work Analogy by the Line; which being done, find (by ſ of the laſt 10 precedent Propoſitions) the Arch or gle anſwering to the *S.* or *T.* &c. found; and the Q ſtion is Solved.

Example.

I would find the Altitude of the Sun at the Hou 6. (in the Lat. of 51 Deg.) when the Sun's Declina is 10 Deg. The Analogy to do it, is, as *R*: *S*, Lat.: Sun's Declination: *S.* Altitude. I aſſume the *R* to 100. Then (by Prop. 1.) I find the *S.* of 51 Deg Lat. to be 76, and the *S.* of 10 Deg. the Declin to be 17. Then I ſay, as 100: 76 : : 17 : 13, whi 13. I turn into Deg. by Prop. 12. and I find it t

$7\frac{1}{2}$ Deg. *Fere*, which is the Altitude ſought. Do the like by any other Queſtion.

CHAP. II.

Of Right-Angl'd Plain Trigonometry.

IN Right-Angl'd Plain Trigonometry, there is commonly reckon'd but 7 different Caſes; I ſhall make 15, (diſtinguiſh'd by their different *Data* and *Quæſita*, and ſhall ſhew ſeveral Rules for the Solution of moſt of them;) all which (for Brevety Sake) I ſhall lay down in a brief Synopſis, as is commonly done in Mathematical Books; but my Synopſis will be ſomewhat different from theirs, becauſe I am willing (in this Book) to avoid the Charge of Cuts. But before I proceed, the Reader may

Note: 1. That in Right-Angl'd plain Triangles, if one of the Oblique Angles be given, the other alſo is given, as being its Complement to 90 Degrees.

2. That in a Right-Angl'd plain Triangle, any of its ſides containing the Right-Angle, may be the Baſe; though commonly the longeſt of thoſe ſides is call'd the Baſe, and the other Perpendicular.

3. That in the following Synopſis, I ſhall (for Brevity-ſake) make uſe of the following Symbols, *viz.*

R. Radius.
S. Sine.
T. Tangent.
Co-S. Co-Sine.
Co-T. Co-Tangent.
Sec. Secant.

B. Baſe.
P. Perpendicular.
H. Hypotenuſe.
∠. Angle.
∠ *B*. Angle at the Baſe.
∠ *P*. Angle at the Perpendicular.

This being premis'd, I here Inſert

The Caſ s of Right Angl'd Plain Triangles.

Caſe	Given	Requir'd	*The Rule.*
I	*∠s & B*	*P*	1. *As S. ∠P : B : : S. ∠B : P. or* 2. *As R : B : : T. ∠B : P. or* 3. *As T. ∠P : B : : R : P.*
II	*Idem*	*H*	1. *As S. ∠P : B : : R : H. or* 2. *As R : B : : Sec. ∠B : H. or* 3. *As T. ∠P : B : : Sec. ∠P : H.*
III	*∠s & P*	*B*	1. *As S. ∠B : P : : S. ∠P. B. or* 2. *As R : P : : T. ∠P : B. or* 4. *As T. ∠B : P : : R : B.*
IV	*Idem*	*H*	1. *As S. ∠B : P : : S. ∠P : B. or* 2. *As R : P : : Sec. ∠P : B. or* 3. *As T. ∠B : P : : R : B.*
V	*∠s & H*	*B*	1. *As R : H : : S. ∠P : B. or* 2. *As Sec. ∠B : H : : R : B. or* 3. *As Sec. ∠P : H : : T. ∠P. B*
VI	*Idem*	*P*	1. *As R : H : : S. ∠B : P. or* 2. *As Sec. ∠P : H : : R : P. or* 3. *As Sec. ∠B : H : : T. ∠B : P*
VII	*B & P*	*∠B*	*As B : R : : P : T. ∠B.*
VIII	*Idem*	*∠P*	*As P : R : : B : T. ∠P.*
IX	*Idem*	*H*	*Find ∠P. by the 8th Caſe, then ſa* *As S. ∠P : B : : R : H.*
X	*B & H*	*∠B*	*As B : R : : H : Sec. ∠B.*
XI	*Idem*	*∠P*	*As H : R : : B : Sec. ∠P.*
XII	*Idem*	*P*	*Find ∠B. by the 10th Caſe, then ſa* *As R : B : : T. ∠B : P.*
XIII	*P & H*	*∠B*	*As H : R : : P : Sec. ∠P.*
XIV	*Idem*	*∠P*	*As P : R : : H : Sec. ∠P.*
XV	*Idem*	*B*	*Find ∠P. by the 4th Caſe, then ſ* *As R : P : : T. ∠P : B.*

The Explanation of the Synopſis, by

Example.

Suppoſe in a Right-Angl'd Triangle, there were given oth the Oblique Angles, and the Baſe; to find the Hypotenuſe. This is the ſecond Caſe; and the fourth Column of the Synopſis ſhews three Rules to ſolve it: e firſt of which is to be read thus; As the Sine of the ngle at the Perpendicular, is to the Baſe; ſo is the adius to the Hypotenuſe. The reſt are to be read the ſame manner. The thing is too plain to need any rther Explanation. I come therefore to

---

CHAP. III.

Of Oblique-Angl'd Plain Trigonometry.

THis I ſhall lay down in a brief Synopſis. But firſt you may

Note: 1. That in all Oblique Angl'd Triangles, if o Angles are given, the third Angle is alſo given, as being Complement of their Sum to 180 Degrees.

2. That here I ſhall make uſe of ſome Symbols not plain'd in the 2d Chapter, and they are theſe, *viz.*

(*Latus*) a Side.	X. Difference.
Sides.	⊏ Greater.
ngle.	⊐ Leſſer.
Angles.	= Equal.
Triangle.	+ Added.
Sum.	— Subtracted.

This being Premiſed, I ſhall now lay down

The Caſe of Oblique Angled Plane Triangles.

Caſe	Given	Requir'd	*The Rule.*
I	2∠s & L. included.	*the other Ls.*	As *S.* 3*d* ∠ : given L :: *S.* ∠ op poſite to *L.* ſought : L ſought.
II	2∠s & L. *oppoſite to one of 'em.*	*the L. oppoſite to the other.*	As S. ∠ oppoſite to the give L : the given L :: *S.* ∠ oppoſit to *L.* ſought : the L. ſought.
III	*Idem.*	*L. includ.*	As *S.* ∠ oppoſite to the give L : given L :: *S.* 3*d* ∠ : ſought.
IV	2Ls & ∠ *included.*	*the other ∠s.*	As Z. given Ls : their *X* :: ½ Z. of the other 2∠s : *T.* their *X.* which ½ Diffe { Add. to / Sub. from } the ½ Z. is { ⊏ / ⊐ } ∠ ſought.
V	*Idem.*	*the 3d* L.	Find the other ∠s. by the 4 Caſe. Then find the 3d by the 2d Caſe.
VI	2Ls & ∠. *oppoſite* 1 *of 'em.*	*∠ oppoſite to the other.*	As one L : S. its oppoſite ∠ the other L : *S.* its oppoſite
VII	*Idem.*	*∠ included.*	Find the other ∠ by the Caſe. Then find ∠ ſought Note 1. of this Chapter.
VIII	*Idem.*	*the 3d* L.	Find ∠ included, by the Caſe. Then find L. ſought the 2d Caſe.

Caſe	Given	Requir'd	*The Rule.*
IX	3*L*s.	*an* ∠.	Divide the Oblique ∠*d* △ into two right ∠*d* ones, by letting fall a *P*. from the Obtuſe ∠. to the ⊏ *L*. thus; ſay, as the ⊏ *L* : *Z*. other 2 *L*s : : *X*. of them 2*L*s : a 4th. Which 4th Sub. from ⊏ *L*. the *P*. will fall in the middle of the Remainder. Then in each of the two right ∠*d*△s is given the *B*. and *H*. Whence the ∠ ſought may be found by the 6th Caſe of right ∠*d* Plain Trigonometry.

Thus I have exhibited eight Caſes in Right-Angl'd, and 4 in Oblique-Angl'd Trigonometry, more than any other Author.

This is ſo plain that it needs no farther Explanation: I ſhall therefore proceed to

CHAP. IV.

Of *Right-Angl'd Spherical Trigonometry.*

I Shall here alſo lay down the Rules for the Solution of

The

The Cases of Right Angled Spheric Triangles.

Caſe	Given	Requ.	*The Rule.*
I	*∠s at P & B*	*H*	*As t.∠P:Co-t.∠B::R.Co-S.H. or* *As R:Co-t.∠B::Co-t.∠P:Co-S.H.*
II	*Idem*	*B*	*As S.∠B : R :: Co-S.∠P:Co-S.P*
III	*Idem*	*P*	*As S.∠P:R::Co-S.∠B:Co-S. P.*
IV	*H&∠B*	*∠P*	*As R : Co-S.H :: t. ∠B:Co-t.∠P.*
V	*Idem*	*P*	*As R : S. H : : S. ∠B : S. P.*
VI	*Idem*	*B*	*As R : Co-S. ∠B : : t. H : t. B.*
VII	*H&∠P*	*∠B*	*As R : Co-S. H::t. ∠P:Co-t. ∠B.*
VIII	*Idem*	*B*	*As R : S. H : : S. ∠P : S. B.*
IX	*Idem*	*P*	*As R : Co-S. ∠P : : t H : t. P.*
X	*B &∠B*	*∠P*	*As R:Co-S. B::S. ∠B:Co-S. ∠P.*
XI	*Idem*	*H*	*As R:Co-S.∠B::Co-t. B:Co-t. H.*
XII	*Idem*	*P*	*As R : S. B : : t. ∠B : t. P.*
XIII	*B& ∠P*	*∠B*	*As R:Co-S.B : : S.∠P:Co-S. ∠B.*
XIV	*Idem*	*H*	*As R:Co-S.∠P::Co-t.B : Co-t.H.*
XV	*Idem*	*P*	*As R : Co-t. ∠P : : t. B : S. P.*
XVI	*P & ∠B*	*∠P*	*As Co-S. P:R::Co-S. ∠B : S. ∠P.*
XVII	*Idem*	*H*	*As S. ∠B : R : : S. P : S. H.*
XVIII	*Idem*	*B*	*As t. ∠B : t. P : : R : S. B. or* *As R : Co-t. ∠B : : t. P : S. B*
XIX	*B &∠P*	*∠B*	*As R:Co-S. P::S. ∠P:Co-S. ∠B*
XX	*Idem*	*H*	*As R:Co-S.∠P :: Co-t.P:Co-t.H*
XXI	*Idem*	*B*	*As R : S. P : : t. ∠P : t. B.*
XXII	*H & B*	*∠P*	*As S. H : R : : S. B : S. ∠P.*
XXIII	*Idem*	*∠B*	*As R : t.B : : Co-t.H:Co-S. ∠B*
XXIV	*Idem*	*P*	*As Co-S. B:R : : Co-S.H:Co-S.P*
XXV	*H & P*	*∠B*	*As S. H : R : : S. P : S. ∠B.*

Ca

Caſe	Given	Requ.	*The Rules.*
XXVI	*Idem*	∠*P*	As *R* : *t.P* :: *Co-t.* *H* : *Co-S.* ∠*P.*
XXVII	*Idem*	*B*	As *Co-S. P* ; *R*::*Co-S.H*:*Co-S.B.*
XXVIII	*B* & *P*	∠*B*	As *R* : *S. B* :: *Co-t. P* : *Co-t.* ∠*B*
XXIX	*Idem*	∠*P*	As *R* : *S. P* :: *Co-t. B* : *Co-t.*∠*P.*
XXX	*Idem*	*H*	As *R*:*Co-S. P*::*Co-S. B* : *Co-S. H.*

Theſe are all the poſſible Caſes of Right-Angl'd Spherical Trigonometry; and here are 14 Caſes more than in any other Author.

CHAP. V.

Of Oblique-Angl'd Spherical Trigonometry.

HEre alſo, I ſhall lay down the Rules for the Solution of

The Caſes of Oblique Angl'd Sph. Triangles.

Caſe	Given	Requir'd.	*The Rule.*
I	2 ∠*s* and *L*. op. to one of them.	*L*. oppoſite to the other.	As *S*. ∠. oppoſite to the given *L* : *S*. given *L* :: *S*. ∠. oppoſite to *L*. ſought : *S*. *L*. ſought.
II	Idem.	*L*. between them.	Find *L*. oppoſite to the other given *L*. by 1ſt Caſe. Then ſay, as *S*. ½ *X* given ∠*S* : *S*. ½ their *Z* :: *T*. ½ *X* given ∠*S* : *T*. ½ *L* ſought.

Caſe

Caſe	Given	Requir'd	*The Rule.*
III	Idem.	the 3d. ∠.	Find ∠. included by 2d Ca. Th. ſay, as S. giv. ∠ : S. ∠. op. to it : : ∠S.∠. laſt ſound: S. ∠ ſou.
IV	2∠S. is ∠. included	the 3d. ∠.	As Co-t. of 1 of the giv. ∠s:R :: Co-S. giv. ∠ : Co t. a 4th. Then if 2d giv. ∠. be $\left\{\begin{matrix}\text{Acute, } Z\\ \text{Obtuſe } X\end{matrix}\right\}$ of this 4th & 2d giv. ∠. is a 5th Then, as S. 4th:S.5th :: Co-S. firſt giv. ∠ : Co-S. ∠. ſought.
V	Idem.	one of the other ∠S.	Find 3d ∠. by 4th Caſe. Then, ſay, as S. 3d ∠ : S. giv. ∠ : : S. ∠. op. to ∠. ſought: S. ∠. ſou.
VI	2 ∠S & ∠. op. to one of them.	∠. oppoſite to the other.	As S. ∠. oppoſite to the giv. ∠: S. given ∠ :: S. ∠. oppoſite to ∠. ſought : S. ∠. ſought.
VII	Idem.	the ∠. included.	As R:Co-S.∠. adj. to the giv.∠: T. giv. ∠: Co-t a 4th. Again, as Co-t. of the ſame ∠:Co-t. of the oth. giv.∠::Co-S.the 4th:Co-S.a 5th. If the gi. ∠. be $\left\{\begin{matrix}\text{Ac. } z\\ \text{Ob. } x\end{matrix}\right\}$ of the 4th & 5th is ∠. ſought.
VIII	Idem.	the 3d. ∠.	As R:Co-S. giv. ∠ :: t. giv. ∠ adj. to the giv.∠:t.4th. Again, as Co-S. of the ſame ∠:Co-S, the oth. giv. ∠::Co-S. the 4th:Co-S.a 5th. Th if the given ∠. be $\left\{\begin{matrix}\text{Ac. } z\\ \text{Ob. } x\end{matrix}\right\}$ of the 4th & 5th is ∠. ſought.

Caſ

Caſe	Given	Requir'd	*The Rule.*
IX	2 *L*s. & ∠ *included.*	*any of the other* ∠s.	As *R* : *Co-S.* given ∠ : : *t.* given *L.* oppoſite to ∠ ſought : *t.* a 4th. Then, if the given ∠ be { Obtuſe, z / Acute, x } of this fourth and the other given *L* is a fifth. Then, as *S.* 5th : *S.* 4th : : *t.* given ∠ : *t.* ∠ ſought.
X	*Idem.*	3*d L.*	Find the other ∠s. by 9 Caſe. Then find the third *L.* by 1ſt Caſe.
XI	3 *L*s.	*any one of the* ∠s.	As the Rectangle of the *S*s. *L*s. containing ∠ req; Square of R : : Rectangle of the *S*s. *X*s. of the ſame *L*s from ½ z of the 3 *L*s : Square *S.* of ½ ∠ ſought.
XII	3 ∠s.	*any one of the* *L*s:	Turn ∠s into *L*s. And then Work as in the 11th Caſe.

Note: There are *6 Caſes* in Oblique-Angl'd Spherical
rigonometry that are call'd *doubtful*; becauſe, un-
ſs the *Affection* of the ſide, or Angle ſought, (*viz.* whe-
er it be greater or leſſer than 90 Deg.) be alſo given,
is uncertain whether you have found the Side or An-
e ſought, or its Complement to 180 Degrees. Theſe
ubtful Caſes are here the 1, 2, 3, 6, 7 and 8.
e Reader may ſee more of this Matter, (with a full
emonſtration of it,) in *Clavius Theodoſium*. Or if the
ader be only an Engliſh Scholar, he may ſee the ſame
anſlated and Inſerted by Mr. *Collins*, in his *Sector* on
Quadrant, or Tranſcribed from Mr. *Collins* (*Verbatim*)
Mr. *Holwel*, in his *Trigonometry made eaſy*. To ſome
theſe Authors I refer the Reader; it being not my

Buſineſs here to teach whole Sciences; but only ſhew the Excellency and Uſefulneſs of the *Line of Nu* *bers* in each.

CHAP. VI.

Of Aſtronomy.

FOr Brevity Sake, I ſhall diſpoſe (according to m uſual Method) the ſeveral Problems of this Chapte in a brief Compendium; which yet I doubt not, but render as plain and intelligible, as thoſe that have ſa ten times as much. But before I proceed further, it w be convenient to explain the Symbols there made uſe o and they are theſe,

R. Radius.
S. Sine.
Co-S. Co-Sine.
t. Tangent.
Co-t. Co-Tangent.
V-S. Verſed-Sine.
Sec. Secant.
⊙ Sun.
☾ Moon.
* Star.
Ln. Longitude.
Lt. Latitude.
Lt-Pl. Latitude of a Place.
Dcl. Declination.
R-*A*. Right Aſcenſion.
O-A. Oblique Aſcenſion.
O-D. Oblique Deſcenſion.
A-X. Aſcenſional Differ.
Az. Azimuth.
Am. Amplitude
Al. Altitude.

Æq.*P*. Æquinoctial-Poin
L-⊙-*Poſ*. Ang. of ⊙ Po
H. Hour.
D. Day.
Ni. Night.
M-D. Mid-Day.
M-N. Mid-Night.
T. Time.
T-D. Time of Day.
T-N. Time of Night.
E. Eaſt.
W. Weſt.
N. North.
S. South.
⊏ Greater, or Greate
⊐ Leſſer or Leaſt.
Z. Sum.
X. Difference.
+ Added.
— Subtracted.

This being Premiſed, I here exhibit the Problems in Aſtronomy

Prob.	to find.	knowing.	*The Rule.*
1	☉Dcl.	☉. *Ln.* from ♈ or ♎.	As *R* : *S.* ☉. ⊏ Dcl : : *S.* ☉. *Ln* from the next *Æq-p.* (either ♈ or ♎) : *S.* ☉ Dcl.
2	☉. *Ln.* from ♈ or ♎	its preſent Dcl.	As *S.* ☉ ⊏ Dcl : *S.* its preſent Dcl. : : *R* : *S.* ☉. *Ln* from the next *Æq p.* either ♈ or ♎.
3	Idem.	its *R-A.*	As *R* : *Co-t.* ☉. *R-A* : : *Co-S.* its ⊏ Dcl : *Co-t.* its *Ln.* from the next *Æq-p.*
4	*A-X.* ☉ or *.	*Lt-Pl.* and ☉ or * Dcl.	As *Co-t. Lt-Pl* : *t.* ☉ or *. Dcl : : *R* : *S.* his *A-X.*
5	☉ *Am.*	*Lt-Pl.* and ☉ *Ln.* from ♈ or ♎	As *Co-S. Lt-Pl* : *S.* ☉. ⊏ Dcl. : : *S.* its *Ln.* from ♈ or ♎ : *S.* its *Am.*
6	*Am.* ☉ or *.	*Lt-Pl.* and ☉ or * Dcl.	As *Co-S. Lt-Pl* : *R* : : *S.* ☉. or *. *Dcl* : *S.* its *Am.* from *E.* or *W.*
	☉R-*A*	its *Ln.* from ♈ ♎.	As *R* : *Co-S.* ☉. ⊏ *Dcl* : : *t.* its *Ln.* from ♈. or ♎ : *t.* its *R-A.*
	Idem.	its Dcl.	As *t.* ☉. ⊏ *Dcl* : *t.* its preſent *Dcl* : : *R* : *S.* its *R-A.*

Prob.	to find	knowing.	_The Rule._
9	_R-A._ of a Planet or fixed *.	its _Ln._ and _Lt._	As _R_ : _S._ *. _Ln._ from ♈ or ♎ : : _Co-t._ its _Lt_ : _t._ a 4th Arch Then, if the *. _Ln._ and _Lt._ b { alike,(_viz._ b._N._ or b._S._)x. } { unlike,(_viz._ 1 _N._& 1 _S._)z. } of this 4th Arch, and ☉ grea ter Dcl. is a 5th Arch. Then as _S._ 4th Arch : _S._ 5th : : _t._ * _Ln_ : _t._ its _R-A._
10	_O-A_ of ☉ or *.	its _R-A_ and _A-X._	Find _A-X._ by Prob. 4. an _R-A._ by Prob. 7, 8, or 9. The if Dcl. be $\left\{\begin{array}{l} N.\ x \\ S.\ z \end{array}\right\}$ _R-A_ an _A-X_ is _O-A._
11	_O-D._ of ☉. or *.	its _R-A._ and _A-X._	Find _A-X._ by Prob. 4. an _R-A._ by Prob. 7, 8, or 9. Th if Dcl. be $\left\{\begin{array}{l} N.\ z \\ S.\ x \end{array}\right\}$ of _R-_ and _A-X_ is _O-D._
12	Dcl. of a Planet or Fixed *.	its _Ln._ and _Lt._	Find a 4th and 5th Arch, Prob. 9. Then ſay, as _Co-_ 4th Arch : _Co-S._ 5th : : _S._ _Lt_ : _S._ its Dcl.
13	∠-☉ Poſ. at its Riſ.	_Lt-Pl._ and ☉. Dcl.	As _Co-S._ ☉. Dcl : _R_ : : _S._ _Pl_ : _S._ ∠-☉-Poſ. at _T._ of Riſing.
14	∠-☉P. at any _T D._	_Lt-Pl._ and _T-D._	As _R_ : _Co-S._ _Lt-Pl_ : : _S._ from _M-N_ : _S._ ∠-☉-Poſ. that _T._
15	∠ Eclip. and Merid.	☉. Great Dcl. and _R-A._	As _R_ : _S._ ☉ Greater Dcl : : _S._ ☉. _R-A_ : _Co-S._ ∠. of Ecliptic and Meridian.

Prob.	to find	knowing.	*The Rule.*
16	☉. *Al*- at *E.* or *W.*	*Lt-Pl.* and ☉. Dcl.	*As S. Lt-Pl* : *S.* Sun's Dcl : : *R* : *S.* its *Al.* when it is due *E.* or *W.*
17	☉ *Al.* at ſix a Clock.	*Lt Pl.* and *Sun's* Dcl.	*As R* : *S. Sun's* Dcl : : *S. Lt.Pl* : *S. Sun's Al.* at ſix a Clock.
18	☉ *Az.* at ſix a Clock.	*Lt-Pl.* and *Sun's* Dcl.	*As Co-S. Lt-Pl* : *R* : : *Co-t. Sun's* Dcl : *t.* its *Az.* (from the *N.*) at ſix a Clock.
19	Meridian *Al.* ☉ or *	*Lt-Pl.* and *Sun* or * Dcl.	If the *Lt-Pl.* & *Sun's* or * Dcl. be { alike, (*viz.* b. *N.* or b. *S.*) z } { unlike, (*viz.* 1 *N.* & 1 *S.*) x } of *Sun* or * Dcl. & *Com. Lt Pl.* is the Meridian *Al.* of *Sun* or *.
20	☉. *Al.* at any *T-D.*	Length of an Object, & of its Shadow.	As the length of the Shadow (of any Object ſet Perpendicular to the Horizon) to the length of the Object ; ſo is *R*, to the *t. Sun's Al.*
21	Idem.	*Lt-Pl.* and *Sun's* Dcl. and *T-D.*	*As R* : *Co-S. T.* from *M-D* : : *Co-t. Lt-Pl* : *t.* a 4th Arch. Which 4th Arch Sub. from the *Sun's* Diſt. from the Pole, leaves a 5th Arch. Then, as *Co-S.* 4th Arch : *Co-S.* 5th : : *S. Lt-Pl* : *S. Sun's Al.* at that *T.*
22	the ſame another way.	the ſame.	*As R* : *Co-S. Lt-Pl* : : *Co-S.* the *Suns* Dcl : a 4th *S.* Again, as *R* : that 4th *S* : : *S. T.* from 6 a Cl. to (in Summer) *X. Ss. Suns Al.* at 6. and of its *Al* ſou. and (in Winter) to *Z. Ss.* its depreſſion at 6, and of its *Al.* ſought.

Prob.	to find.	knowing.	*The Rule.*
23	the ſame.	*Lt-Pl.* & the *Suns* Dcl. and *T-D.* and the *Suns* Mer. *Al.*	As the Cube of *R* : double Rectangle of the *Co-Ss.* of *Lt.Pl.* & ☉ Dcl : : ſquare *S.* $\frac{1}{2}$. *T.* from *M-D* : *X. Ss.* ☉ Meridian *Al.* & *Al.* ſought. (The Merid. *Al.* is found by Prob. 19.)
24	*Sun's Al.* on any *Az.* ☉ be. in the Equin.	*Lt-Pl.* & the *Sun's Az.* from *S.*	*As R* : *Co-S.* the *Sun's Az.* fr. South : : *Co-t. Lt-Pl* : *t. Sun's Al.* upon that *Az.* (the *Sun* being in the Equinox.
25	☉ *Al.* upon any *Az.* at any *T.*	☉ *Al.* upon that *Az.* in the Equinox. And the Θ preſent Dcl.	Find the *Suns Al.* up. that *Az.* in the Equin. by Prob. 24. Then ſay, as *S. Lt-Pl* : *S. Sun's Dcl* : *Co-S. Sun's Al.* on th. *Az.* i the Equ: *S.* a 4th Arch. Then, i the *Lt-Pl.* & the *Sun's* Dcl. b { alike, (*viz.* b. *N* or b. *S.*) z } { unlike, (*viz.* 1 *N.* & 1 *S.*) x } of 4th Arch, and the *Sun's A* in the Equinox is *Al.* ſought But in all *Az's.* betwixt th *N.* and *E.* or *N.* and *W.* uſe Z for *X.* and *è Contra.*
26	☉ *Az.* at any *T.D.*	the *Sun's* Dcl. & *Al.* & *T-D.*	*As Co-S.* the *Sun's Al* : *S. T* from *M-D* : : *Co-S.* the *Sun* Dcl : *S.* its *Az.* from the *N.*
27	*Az.* ☉ or * at any *T.*	*Lt-Pl.* & the *Sun* or *, Dcl. and *Al.*	*As R* : *Co-S. Lt-Pl* : : *Co-S. Al* : 4th *S.* Again, as the 4th *S* : $\frac{1}{2}$ Z. of the Complem. of the *Data* : : *S. X.* that $\frac{1}{2}$ Z. & *Co* *Dcl* : a 7th *S.* Which multip by *R.* the ſquare Root of th Product is *S.* $\frac{1}{2}$ *Az.* fr. South

Pro

Prob.	to find	knowing	*The Rule.*
28	the ſame another way.	the ſame.	*As R* : *S. Lt-Pl* :: *S. Al* : a 4th *S.* Again, as *Co-S. Lt-Pl* : *Sec. Al* :: ſo (if Dcl. be towards the $\left\{\begin{matrix}\text{elevated}\\\text{depreſſed}\end{matrix}\right\}$ Pole) is $\left\{\begin{matrix}X\\Z\end{matrix}\right\}$ of the 4th *S.* and *S.* Dcl : *S. Az.* from *E.* or *W.*
29	the ſame another way.	the ſame.	As the Rectangle of the *Ss. Co-Lt-Pl.* and *Co-Al* : ſquare *R* :: Rectangle *Ss. Xs.* of *Co-Lt-Pl.* & *Co-Al.* from ½ z. *Co-Lt-Pl. Co-Al.* and *Co-Dcl* : ſquare *S.* ½ *Az.* from the *N.*
30	*T.* ⊙ com. to *E.* or *W*	*Lt-Pl.* & the *Sun's* Dcl.	*As t. Lt-Pl* : *t.* the *Sun's* Dcl :: *R* : *Co-S. T.* from *M-D.*
31	the *Suns* Riſing and Set.	*Lt-Pl.* & the *Sun's* Dcl.	Find the *Sun's A-X.* by Prob. 4. Then, *A-X* $\left\{\begin{matrix}\text{Sub. fr.}\\\text{Add. to}\end{matrix}\right\}$ 6 Ho when ⊙. is in ♈ ♉ ♊ ♋ ♌ or ♍ gives ⊙ $\left\{\begin{matrix}\text{Riſing.}\\\text{Setting.}\end{matrix}\right\}$ And the ſame $\left\{\begin{matrix}\text{Add. to}\\\text{Sub. fr.}\end{matrix}\right\}$ 6 Hours, when ⊙ is in ♎ ♏ ♐ ♑ ♒ or ♓. gives ⊙ $\left\{\begin{matrix}\text{Riſing.}\\\text{Setting.}\end{matrix}\right.$
32	⊙ Semi-Di. Ar. & length of *D.*	*Lt-Pl.* & the *Sun's* Dcl.	Find the *T.* of the *Suns* ſetting by Prob. 31. for that is the *Sun's* Semi-Diurnal-Arch; which doubled gives the Length of the Day.

Prob.

Prob.	to find	knowing.	*The Rule*
33	Time of the Day.	*Lt-Pl.* ⊙ Dcl. and Meridian and preſent *Al.*	*As R* : *Co-S.* the *Suns* Dcl :: *Co-S. Lt-Pl* : a 4th S. Again, as that 4th. *S* : *R* :: *X. Ss* of the Meridian and preſent *Al* : *V-s. T.* from *M-D.* The Meridian *Al.* is found by Prob. 19.
34	the ſa.	*Lt-Pl.* & the *Sun's* Dcl. & *Al.*	Find the *Sun* Meridian *Al.* by Prob. 19. and its Semi-Diurnal Arch, by Prob. 32. Then ſay, as S. Meridian *Al* : *S.* preſent *Al* :: *S.* Semi-Diurnal-Arch : *S. T.* from the *Sun* Riſing, or Setting.
35	the ſame another way	the ſame.	*As R* : *Co-S. Lt-Pl* :: *Co-S. Al* : a 4th *S.* Again, as that 4th *S* : *S* $\frac{1}{2}$z. Complements 3 *Data* :: *S. X.* that $\frac{1}{2}$z. from the Compl. *Al* : a 7th *S.* which multiplied by *R.* the ſquare Root of the Product is *S.* $\frac{1}{2}$ *T.* fr. Noon.
36	the ſame another way.	the ſame.	*As R* : *S. Lt-Pl* :: *S.* ⊙ Dcl *S.* a 4th (wch. in { Sumr. ⊙. *Alt.* / Wint. ⊙. *Depr.* } at 6 a Clock.) Th. as *Co-S.* Dcl : *Sec. Lt-Pl* :: (in { Sum. x / Win. z } *S's.* of *Al.* given & the { *Al.* / *De.* } at 6 a Clock : *S. T.* from towards *M-D.* in Winter ; & i Sum. alſo, when the given *Al.* greater than *Al.* at 6, but whe 'tis leſſer, towards *M-N.*

Pro

Prob.	to find	knowing.	*The Rule.*
37	Idem	*Lt-Pl.* the *Suns* Dcl. & *Al.* and Semidiur. Arch.	*As* R : *t. Lt-Pl* : : *t.* ☉ Dcl : *S.* a 4th. (which 4th is *T.* ☉ Riſing from 6 a Clock.) Again, as Rectangle *Co-S. Lt-Pl.* & *Co-S.* the *Sun's* Dcl : ſquare R : : S. *Al* : *X. V-S's.* of the Semidiurnal Arch and of *T.* ſought.
38	Idem.	the *Suns* Dcl. *Al.* and *Az.*	*As Co-S.* the *Suns* Dcl : *S.* its *Az.* from *N* : : *Co-S.* its *Al* : *S. T.* from Noon.
39	*Lt-Pl.*	the *Suns* Dcl. and *A-X.*	*As S.* the *Sun's A-X* : R : : *t.* the *Sun's* Dcl : *Co-t. Lt-Pl.*
40	Idem.	the *Sun* or * *Am.* and Dcl.	*As* the *Suns* or * *Am* : *S.* its Dcl : R . *Co-S. Lt-Pl.*
41	Idem.	☉. Dcl. & *T.* at *E.* or *W.*	*As Co-S. T.* from Noon : R : : *t.* the *Sun's* Dcl : *t. Lt-Pl.*
42	Idem.	☉. Dcl. & *Al.* when *E.* or *W.*	*As* S. the *Sun's Al.* when *E.* or *W* : R : : S. the *Sun's* Dcl : S. *Lt-Pl.*
43	Idem.	the *Suns* Dcl. and *Az.* at 6.	*As t.* the *Suns Az.* at ſix a Clock : *Co-t.* its *Dcl* : : R : *Co-S. Lt-Pl.*
44	Idem.	☉. *Al.* & *Az.* at any *T-D.* ☉ being in the Equi.	*As Co-S.* the *Sun's Az* from the South (the *Sun's* being in the Equinox) : R : : *t.* the *Sun's Al.* on that *Az* : *Co-t. Lt-Pl.*
45	*T.* ☾ coming to *S.*	☾ Age.	As 5 : 4 : : ☾. Age (in Days) : *T.* ☾. coming to *S.* (in Hours Afternoon.)

Prob.

Prob.	to find	knowing.	*The Rule.*
46	☾ Set. in the Increa. & Riſ. in the Decreaſe.	☾ Age.	As 5 : 4 : : ſo in the { Incr. Decr. } is the { ☾ Age (in Days) 30 leſs ☾ Age. } : to the *T.* (in Hours) that the ☾ { Sets after Riſes before } the *Sun.*
47	*T-N.* by the ☾.	☾ Age.	Find the ☾ Southing by Prob. 45. Then (by the ſhadow caſt on a Sun-Dial) ſee how much it wants of, or is paſt the *S.* which *T.* ſubtr. from, or added to the Southing gives *T-N :*
48	*T.* of any Pl. or fixt * coming to the *S.*	its *In.* and *It.*	Find the *Sun's R-A* by Prob. 7. or 8 and * *R-A.* by Prob. 9. Then, if the *Sun's R-A* Subtr. from * *R-A.* (adding 360 Deg. or 24 Ho. to * *R-A.* if it be the leſſer than the Sun *R-A*) leaves *T.* *'s coming to *S.*
49	Riſing or Set. of any Planet fix'd *.	*It-Pl.* and *Dcl. and *T.* of its Southing.	Find * *A-X.* by Prob. 4. Then, *A-X.* { Add. to Sub. fr. } 6 Ho. when Dcl. is { N. S. } gives an Arch, which { Add. to Subt. fr. } *T.* *. Sout. gives *T.* its { Setting. Riſing. }

Prob.	to find	knowing	*The Rule.*
50	T-N. by the Plan. or fixt Stars.	Lt-Pl. & * Dcl. & Al.	Find * Meridian Al. by Prob. 19. and T. its Southing by Prob. 48. Then ſay, As R : Co-S. *. Dcl : : Co-S. Lt-Pl : a 4th S. Again, as that 4th S : R : : X. S's. * Meridian and Preſent Al : V-S. *. Diſtance (in T.) from the Meridian. Therefore, if T. thus found be $\left\{\begin{array}{l}\text{Added to}\\\text{Subtr. from}\end{array}\right\}$ T. * Southing, when * is in $\left\{\begin{array}{l}\text{W. Sum.}\\\text{E. Rem.}\end{array}\right\}$ is T-Night.
51	the ſame another way.	the ſame.	Find * Southing, by Prob. 48. Then ſay, as R : Co-S. Lt-Pl : : Co-S. *. Al : a 4th S. Again, as this 4th S : S. $\frac{1}{2}$ Z Complements of the 3 Data : : S. X. of that $\frac{1}{2}$ z. from the Compl. Al : a 7th S. which multiplied by R. the Square Root of the Product is S. $\frac{1}{2}$ T. * wants of, or is paſt the Meridian. And this T. $\left\{\begin{array}{l}\text{Added to}\\\text{Subſtracted from}\end{array}\right\}$ T. ✱ Southing, gives the Time of the Night.

The Uſe of the foregoing Compendium,

Is very eaſy. For in the firſt Column, the Problems re Numbered ; the ſecond, exhibits what is requir'd ; e third, what is given ; and the fourth, ſhews the ule by which each Problem is ſolved. So that, the firſt

Column ſhews the Number of each Problem; the ſecond and third, its Title; and the 4th, the Rule for its Solution.

Example.

The firſt Problem is to be read thus, *Problem the firſt. To find the Sun's Declination, by knowing its Longitude from Aries or Libra. The Rule. As Radius, to the Sine of the Sun's greateſt Declination; ſo is the Sine of the Sun' Longitude from the next Equinoctial Point (either ♈ or ♎ to the Sine of the Sun's Declination.*

In the ſame manner are all the reſt of the Problems t be read. I preſume the thing is too plain to need anothe Example. If any thing ſeem difficult, it is by reaſon of the Symbols; which yet are ſo naturally adapted t the things they are to ſignify, that any one (tho' but o an ordinary Capacity) may eaſily learn them all in hal an Hour.

I ſhall therefore only add a few Notes, upon ſome o the Problems, and ſo conclude this Chapter.

Notes upon

Prob. 1. The ☉. greateſt Dcl. is always 23 Degre and 29 Minutes.

Prob. 10. This Rule is made for *N.* Latitudes. In *S* Latitudes, if Dcl. be $\left\{\begin{matrix} N.\,z \\ S.\,x \end{matrix}\right\}$ of *R-A* and *A-X* *O-A.*

Prob. 11. In *S.* Latitudes work as is directed in th Note on Prob. 10.

Prob. 31. In *S.* Latitudes uſe Addition for Subtractio and the contrary.

Prob. 49. In *S* Latitudes, the *A-X* muſt be $\left\{\begin{matrix} + \\ - \end{matrix}\right.$ when the Dcl. is $\left\{\begin{matrix} S. \\ N. \end{matrix}\right.$

CHAP

CHAP. VII.

Of Geography.

THe Pritcipal and moſt uſual Problems in Geography, are thoſe that follow.

PROB. 1.

o reduce Great Circle Degrees (as of the Equinoct, or Meridian, &c.) into Engliſh Miles.

The RULE.

Say, as 1 : 70 :: the given Number of Degrees : the iles anſwering thereto.

PROB. 2.

o reduce the Degrees of any Parallel of Latitude, into Engliſh Miles.

The RULE.

As R to *Co-S. Lt.* of the Parallel ; ſo is any Number of egrees in that Parallel, to the Great Circle Degrees ſwering thereto. Which turn'd into Miles (by Prob. .) gives the Anſwer.

PROB. 3.

wo Places which differ only in Lt. To find their Diſtance.

The RULE.

If the two Places lye $\left\{\begin{array}{l}\text{both } N. \text{ or both } S.\\ \text{one } N. \text{ and one } S.\end{array}\right\}$ of the uinox, $\left\{\begin{array}{l}\text{x.}\\ \text{z.}\end{array}\right\}$ of their Latitudes turn'd into Miles, Prob. 1.) gives their Diſtance.

PROB. 4.

o Places which differ only in Lng. To find their Diſtance.

The RULE.

1. If the two Places lye both under the Equinox, the *X Lng* (if it be leſs than 180 Deg.) turn'd into Mile (by Prob. 1.) gives their Diſtance. But if their *X L* exceed 180 Degrees, take its Complement to 360 De and work as before.

2. If the two places lye (not under the Equinox, bu under ſome Parallel of *Lt.* Say, as *R* : *Co-S* comm *Lt* : : $\frac{1}{2}$ *X Lng* : $\frac{1}{2}$ Diſtance in Degrees, which turn'd in Miles, (by Prob. 1.) gives the Diſtance ſought.

PROB. 5.

Two Places differing both in Long. and Lat. To fi their Diſtance.

The RULE.

1. If one of the Places lye under the Equinox, and t other under ſome Parallel of *Lt.* Say, as *R* : *Co-S.* of their *X Lng* : : *Co-S. Lt. Co-S.* their Diſtance in De which turn'd into Miles (by Prob. 1.) gives t Anſwer.

2. If both Places lye without the Equinox, but the ſame ſide, (*viz.* both North or both South of i then ſay, as *R* : *Co-S* their *X Lng* : : *Co-t.* Greater *Lt* a 4th; which taken from the Compl. Leſſer *Lt.* lea a 5th. Then, as *S.* 4th : *S.* 5th : : *Co-S.* Greater *S.* Diſtance in Degrees, which turn'd into Miles (by Prob. is the Anſwer.

3. If the two Places lye, one in *N. Lt.* and the ot in *S. Lt.* Then ſay, as *R* : *Co-S*, of their *X Lng* : Greater *Lt* : *t.* a 4th; which taken from the Com Leſſer *Lt*, the Remainder will be a 5th. Then ſay, *Co-S.* 4th : *Co-S.* 5th : : *S.* Greater *Lt* : *Co S.* Diſtanc Degrees, which turn'd into Miles (by Prob. 1.) g the Anſwer, requir'd.

Theſe are all the moſt uſual Problems in Geograp except what relate to finding the Longitude, Latit nd bearing of Places; the two former of which, as hey are found by Calculation, they belong as properly o Navigation; to which therefore (together with the Bearing of Places) I ſhall refer them: Concluding this hapter with

A brief Explication of the Symbols, made uſe of or brevity ſake) in the foregoing Problems.

ng. Longitude.
t. Latitude.
ſt. Diſtance.
. Difference.
. Sum.
. Greater.
. Leſſer.

S. South.
N. North.
Compl. Complement.
XLng. Difference of Longitude.
XLt. Difference of Latitude.

CHAP. VIII.

Of Navigation.

THe principal and moſt uſual Problems in Navigation are ſuch as relate to finding the Longitude, Latide, Rumb, and Diſtance of places; any two of hich being known, the other two may be found, by e Rules in the following

Problems in Navigation.

rob.	knowing	to find	*The Rule.*
1	Lng. & Lt. of 2 Pls.	Rmb.	*As X. Lt : X. Lng : : R : t. Rmb.*
2		Dſt.	*As S. Rmb : R : : X. Lng : Dſt.*
3	Lng. 2 Pls. and Lt. of 1 of them and Rmb.	Lt. of other.	*As S. Rmb : Co-S. Rmb : : X. Lng : X. Lt.*
4		Dſt.	*As S. Rmb : R : : X. Lng : Diſt.*

Prob.	knowing	to find	*The Rule.*
5	Lng. two Pls. & Lt. one them, & Diſt.	Rmb.	*As Dſt* : *X. Lng* : : R : *S. Rmb.*
6		Lt. of the other.	*Find Rmb.* by *Prob.* 5. Then ſay, *As S. Rmb* : *Co-S. Rmb* : : *X. Lng* : *X. Lt.*
7	Lt. 2 Pls. and Lng. 1 of 'em and Rmb.	Lng. of the other.	*As Co-S. Rmb* : *S. Rmb* : : *X. Lt* : *X. Lng.*
8		Diſt.	*As Co-S. Rmb* : R : : *X. Lt* : *Dſt.*
9	Lt. 2 Pls. and Lng. 1 of them and Dſt.	Rmb.	*As X. Lt* : *Dſt* : : R : *Sec. Rmb.*
10		Lng. of the other.	*Find Rmb.* by *Prob.* 9. Then, *As Co-S. Rmb* : *S. Rmb* : : *X. Lt* : *X. Lng.*
11	Rmb. & Dſt. two Pls. and Lng. or Lt. of one of them.	Lng. of the other.	*As R* : *S* : *Rmb* : : *Dſt* : *X. Lng*
12		Lt. of the other.	*As R* : *Co-S. Rmb* : : *Dſt* : *X. Lt*

The uſe of the foregoing Problems, will be made evident by the following Notes.

Note 1. That the Symbols made uſe of in theſe Problems, are theſe that follow.

Lng. Longitude.
Lt. Latitude.
Rmb. Rumb.
Dſt. Diſtance.
Pls. Places.

X. Lng. Difference of Lo
gitude.
X. Lt. Difference of La
tude.

Note 2. If the $\left\{\begin{matrix}Lng.\\ Lt.\end{matrix}\right\}$ of two *Pls.* be given; Su tract the leſſer from the greater, the remainder is t $\left\{\begin{matrix}X.\ Lng.\\ X.\ Lt.\end{matrix}\right\}$ of thoſe two Places.

Note 3. The *X. Lng.* or *X. Lt.* being thus found, in
eg. reduce the *X. Lt.* into Miles by Chap. 7 Prob. 1.
f this Book. Alſo, reduce the *X. Lng.* into Miles,
y Chap. 7. Prob. 2 of this Book. But, in reducing
e *X. Lng.* into Miles, obſerve to do it for *that* Paral-
l of *Lt.* (not *from* which, but) *towards* which you are
iling.

Note 4. If the Rumb be given (as commonly it is)
Points of the Compaſs; it muſt be reduced into Deg.
y allowing 11 Degrees 15 Minutes for each Point of
e Compaſs.

Note 5. The Rumb is always accounted from the Me-
dian, towards the Eaſt or Weſt, whether you ſail to-
ards the North or South.

Note 6. The five precedent Notes being known; any
f the 12 Problems, in the foregoing Table, are
lv'd, by the Analogy in the fourth Column.

Note 7. The *X. Lng.* or *X. Lt.* found by any of the
oblems in this Table, is found in Miles; and muſt be
duced into Degrees, before you can find the *Lng.* or *Lt.*
f the place ſought.

Note 8. The *X.* of $\left\{\begin{matrix}\textit{Lng,}\\ \textit{Lt.}\end{matrix}\right\}$ in Miles may be reduced
o Degrees, by Prob. $\left\{\begin{matrix}13\\ 14\end{matrix}\right\}$ of this Chapter.

Note 9. The *X. Lng.* or *X. Lt.* being thus found, in
egrees; If you ſeek the *Lng.* of a Place $\left\{\begin{matrix}\text{Add}\\ \text{Subtract}\end{matrix}\right\}$
e *X. Lng.* $\left\{\begin{matrix}\text{to}\\ \text{from}\end{matrix}\right\}$ the *Lng.* of the Place given, if
u ſail $\left\{\begin{matrix}\text{Eaſterly}\\ \text{Weſterly}\end{matrix}\right\}$ from the Place of known *Lng.*
d the $\left\{\begin{matrix}\text{Sum}\\ \text{Remainder}\end{matrix}\right\}$ is the *Lng.* of the Place
ught.

In like manner, if you ſeek the Latitude of a Place, {Add / Subtract} the X. *Lt.* {to / from} the *Lt.* of the Place given, if you ſail towards the {Pole; / Equinox;} and the {Sum / Remainder} is the *Lt.* of the Place ſought.

Note 10. The Rumb being found by any of the Problems of this Table, is found in Degrees; and muſt be reduced into Points of the Compaſs, by allowing 11 Deg. 15 Min. for each Point. Then, theſe Points of the Compaſs are to be reckon'd from the North or South Points of the Horizon, towards the Eaſt or Weſt, and ſo to be denominated reſpectively, as your own Reoſon will eaſily guide you.

Note 11. Becauſe (perhaps) every one (into whoſe Hands this Book may come) cannot tell the Names of the 32 Points of the Mariners Compaſs; it may not be much amiſs here to inſert them, according to their Order; and they are theſe,

1. North, or full North.
2. North and by Eaſt.
3. North North-Eaſt.
4. North-Eaſt and by [redacted]. North
5. North-Eaſt.
6. North-Eaſt and by Eaſt.
7. Eaſt North-Eaſt.
8. Eaſt and by North.
9. Eaſt or full Eaſt.
10. Eaſt and by South.
11. Eaſt South-Eaſt.
12. South-Eaſt, & by Eaſt.
13. South-Eaſt.
14. South-Eaſt & by South.
15. South South-Eaſt.
16. South and by Eaſt.
17. South, or full South.
18. South and by Weſt.
19. South South-Weſt.

20. South-Weſt and by South.
21. South-Weſt.
22. South Weſt & by Weſt.
23. Weſt South-Weſt.
24. Weſt and by South.
25. Weſt or full Weſt.
46. Weſt and by North.
27. Weſt South-Weſt.
28. North-Weſt & by Weſt.
29. North-Weſt.
30. North-Weſt & by North.
31. North North-Weſt.
32. North and by Weſt.

And ſo, the next Point comes round to the North again.

Other Problems uſeful in Navigation, are theſe that follow.

PROB. 13.

To reduce Miles into Great Circle Degrees, (as of the Equinox, or Meridian, &c.*)*

The RULE,

As 70 : 1 : : the given Number Miles : the Degrees nſwering thereto.

PROB. 14.

To reduce Miles into Degrees of any Parallel of Latitude.

The RULE.

Reduce the given Miles into great Circle Degrees, by rob. 13. Then ſay, as *Co.S. Lt* of the Parallel : *R* : : he Number of Great-Circle-Degrees : the Number of egrees in that Parallel, anſwering thereto.

PROB. 15.

o find how many Miles anſwer to one Degree of Latitude in any Rumb.

The

The RULE.

As *Co-S. Rmb.* from the Meridian : *R* : : 70 : the Number of Miles anſwering to one Degree in that Rumb.

PROB. $\left\{\begin{matrix}16.\\17.\end{matrix}\right.$

To reduce $\left\{\begin{matrix}\textit{Miles}\\\textit{Leagues}\end{matrix}\right\}$ *into* $\left\{\begin{matrix}\textit{Leagues.}\\\textit{Miles.}\end{matrix}\right.$

The RULE.

As $\left\{\begin{matrix}3:1::\\1:3::\end{matrix}\right\}$ the given Number of $\left\{\begin{matrix}\text{Miles :}\\\text{Leagues :}\end{matrix}\right\}$ to the Number of $\left\{\begin{matrix}\text{Leagues}\\\text{Miles}\end{matrix}\right\}$ anſwering thereto.

CHAP. IX.

Of Dialing.

THe Principal Problems in Dialing, are ſuch as relate to find the Hour Diſtances, and other Requiſits of a Sun-Dial; the Method of performing which, I ſhall briefly, yet plainly ſhew in this Chapter. But before I ſhew how to Calculate the Hour-Diſtances, it will be neceſſary (becauſe it muſt be firſt known) that I ſhew how ———

To find the Requiſits belonging to any Sun-Dial, *&c.*

§. 1. *For an Horizontal-Dial.*

In *this* there is nothing requir'd but the *Hight of th* *Stile above the Plain*; and *that* is always equal to th Latitude of the Place.

§. 2. *Direct Vertical North or South Plains.*

In theſe Plains alſo, there is nothing requir'd but th hight of the Stile above the Plain; and that is always equal to the Compl. of the Latitude of the Place.

§. 4

§. 3. *Vertical Declining Plains.*

In theſe Plains (before the Hour-diſtances can be Calculated) three things (beſides *Lt-Pl.* and *Dcl. Pln*) muſt be found, of which in their Order, &c.

Prob. 1. *To find the Stile's Hight.*

Say, as *R* : *Co-S. Lt-Pl* : : *Co-S. Dcl-Pln* : S. of the Stile's Hight.

Prob. 2. *To find the Subſtile's Dſt. from the Meridian.*

Say, as R : S. *Dcl-Pln* : : *Co-t. Lt-Pl* : *t. Dſt.* of the Subſtile from the Meridian.

Prob. 3. *To find the Plain's X-Lng.*

Say, as *Co-S. Lt-Pl* : *R* : : S. Subſtil's Dſt. from the Meridian : S. Plain's X-Lng.

§. 4. *Eaſt or Weſt Reclining or Inclining Plains.*

In theſe Plains (as in Vertical Decliners) three things (beſides the Latitude and Reclination) muſt be found, before the Hour-Diſtances can be Calculated ; and they are the ſame as in the other, of which in their Order. And,

Prob. 1. *To find the Stiles Hight.*

Say, as R : *S. Lt-Pl* : : *S.* Reclination : *S.* Stile's Hight above the Plain.

Prob. 2. *To find the Subſtile's Dſt. from the Meridian.*

Say as, *R* : *Co-S.* Reclination : : *t. Lt-Pl* : *t.* Subſtile's Dſt. from the Meridian.

Prob. 3. *To find the Plain's XLng.*

Say, as *S. Lt-Pl* : : *R* : *S.* Subſtile's Dſt. from the Meridian : *S.* Plain's *X. Lng.*

§. 5. *South Declining* $\left\{\begin{array}{l}\textit{Reclining}\\ \textit{Inclining}\end{array}\right\}$ *Plains.*

In theſe Plains beſides the *Lt-Pl.* the Dcl. and Reclination, or Inclination of the Plain, four things muſt be found, before the Hours can be drawn, of which in order. And,

Prob. 1. *To find the Dſt. of the Meridian and Horizon.*

Say, as *R* : *S.* Reclination or Inclination : : *t. Dcl* : *t. Dſt.* of the Meridian and Horizon.

Prob. 2. *To find the Stile's Hight.*

Say, as *R* : *S. Dſt.* Meridian and Horizon : : *Co-S.* Reclination, or Inclination : *S.* a 4th Arch; which Subtracted from the *Lt-Pl.* leaves a 5th Arch. Then ſay, as *S. Dſt.* Meridian and Horizon : *S.* 5th Arch : : *Co-S. Dcl-Pln* : *S.* Stile's Hight.

Prob. 3. *To find Dſt. Subſtile from the Meridian.*

Say, as *Co-t. Dcl-Pln* : *t.* Stile's Hight : : that 4th *S.* (in the preceding Prob.) : *S.* Subſtile's Dſt. from the Meridian.

Prob. 4. *To find the Plain's XLng.*

Say, as the 5th *S.* (found in the foregoing Prob. 2.) *R* : : *S.* Subſtile's Dſt. from the Meridian : *S.* Plain's *XLng.*

§. 6. *North Declining* $\left\{\begin{array}{l}\textit{Reclining}\\ \textit{Inclining}\end{array}\right\}$ *Plain's.*

In theſe Plains (as in South Decliners Reclining) the ſame four things muſt be found, before the Hour Diſtances can be obtain'd, of which in Order. And

Prob. 1. *To find the Dſt. of the Meridian and Horizon.*

Say, as *R* : *S* : Reclination or Inclination : : *t. Dcl-Pln* : *Co-t.* Dſt. Meridian and Horizon.

Prob. 2. *To find the Stile's Hight.*

Say. as *S. Dcl-Pln* : *R* : : *Co-S. Dſt.* Meridian and Horizon : *S.* a 4th Arch, to which add the *Compl. Lt-Pl.* then the Compl. of that Sum to 180Deg. ſhall be a 5th

Arch. Then ſay, as *S.* 4th Arch : *S.* 5th :: *S.* Reclination : *S.* Stile's Hight.

Prob. 3. *To find Dſt. Subſtile from the Meridian.*

Say, as *t.* Reclination : *Co-S. Dſt.* Meridian and Horizon : : *t.* Stile's Hight : *S.* a 4th Arch. Which Arch, or its Compl. to 180. Deg. is the Subſtile's Dſt. from the Meridian, according as you count it from the North or South.

Prob. 4. *To find the Plain's XLng.*

Say, as *S.* Stile's Hight : R : : *t. Dſt.* Subſtile and Meridian : *Co-t.* a 4th Arch. Which Arch is the Plain's *XLng.* from the North; or its Compl. to 180 Deg. if you account it from the South.

§. 7. *Direct South and North Reclining Plains.*

In theſe Plains there is nothing requir'd, before the Hour-Diſtances be Calculated, but the Stile's Hight; which may eaſily be found thus ——

1. *For South Recliners.*

If the Reclination be $\left\{\begin{matrix}\text{leſs}\\ \text{more}\end{matrix}\right\}$ than the *Compl. Lt-Pl.* then the $\left\{\begin{matrix}X.\\ Z.\end{matrix}\right\}$ of the Reclination and *Compl. Lt-Pl.* is the Stile's Hight.

2. *For the North Recliners.*

Add the Reclination to the *Compl. Lt-Pl.* and their Sum, (if leſs than 90 Deg.) or its Complement to 180 Deg. (if more than 90 Deg.) is the Stile's Hight.

§. 8. *To Calculate the Hour-Diſtances upon all ſorts of Plains.*

Upon all Horizontal, and upon all Direct North and South Plains, whether Erect, or Reclining, the Stile ſtands upon the 12 a Clock Line; for theſe Plains have no *XLng.* and therefore the Subſtile and Hour-Line of

12, are the ſame, and the Equinoctial Diſtances of each Hour from 12, is 15 Degrees.

In all other Plains (as Erect Decliners, and North and South Recliners declining,) which have *XLng.* the Plain's *XLng.* muſt be reduc'd into time, by allowing 15 Deg. for one Hour, *i. e.* one Deg. for 4 Min. of Time; and ſo having found the Equinoctial Diſtances of the Hours on either ſide of the Subſtile; the Equinoctial Diſtances for all the other Hours, are eaſily found, by the continual Addition of 15 Deg. for an Hour, and then the Proportion will be

As *R* : *S*. Stiles Hight above any Plain whatſoever i be : : *t*. of the Equinoctial Dſt. of any Hours from th *Meridian* of any direct North or South Plain, whethe Erect or Reclining : — but from the Subſtile of all othe Plains : to the *t*. of the true Hour-Dſt. upon the Plain from the Meridian, or Subſtile.

I ſhall conclude this third Book, with

A brief Explanation of the Symbols made uſe o (for brevity ſake) in this Chapter.

R. Radius.
S. Sine.
t. Tangent.
Co-S. Co-Sine.
Co-t. Co-Tangent.
X. Difference.
Z. Sum.
X-Lng. Difference of Longitude.

i. e. That is
Compl. Complement.
Dcl. Declination.
Dſt. Diſtance.
Lt-Pl. Latitude of a Place.
Dcl-Pln. Declination of th Plain.

BOOK IV.

f the Uſe of the Line of Numbers, in Chronology, Dioptricks, Gunnery, Architecture
Military, or Fortification,
Civil, } *Mechanick-*
Nautical,
Powers, Automaticks or Clock-Work, and Philoſophy.

PROEME.

T cannot be expected, That I ſhould here teach the *Whole* of each Science here mention'd; becauſe each them (when largely explain'd) is capable to fill a ok as big as this is intended: wherefore my Buſineſs e, ſhall be only to ſhew how to ſolve all the moſt al and moſt uſeful Propoſitions in each, by the Line of mbers: Which I ſhall endeavour to do in 9 Chapters. ereof ———

hap. 1. Shall treat of Chronology: Shewing how nd the Golden-Number, Epact, Dominical Letter, cle of the Sun, Roman Indiction, Number of Di-ion, Moveable Feaſts, New and Full Moon in every nth, *&c.* for any Year paſt, preſent or to come; lſo, whether any Year be Leap-Year, or what Year ; what Day of the Week begins the Year; the f the Moon for any Day of any Month, *&c.*

hap. 2 Of Dioptricks; ſhewing how to find the lute and Reſpective Focus's of Convex, Concave and Meniſcus Glaſſes; either ſingle or combin'd; as alſo, to find how much they Magnify, either ſingle o combin'd in Teleſcopes, or Microſcopes, &c.

Chap. 3. Of Gunnery, ſhewing how to find th Weight of ſeveral pieces of Ordnance: the Quantit of Powder to charge them; the Weight of their Bu lets, &c. the diſtance they will carry, Point blank or at any Degree of Mounture, &c.

Chap. 4. Of Military-Architecture or Fortification ſhewing how to make any Regular Fortification, fro the Tetragon to the Dodecagon.

Chap. 5. Of civil Architecture; ſhewing how to fin the length of Timber in a Building, &c.

Chap. 6. Of Nautical Architecture; ſhewing ho to find the length of Timber in a ſhip; with i Burden, &c.

Chap. 7. Of the Mechanick Powers; ſhewing ho to find the Force or Power of any Leaver, Wheel, Pu ley, Wedge, Skrew, or Inclining plane, or of any M chine compos'd of any two or more of theſe Mech nick Powers, &c.

Chap. 8. Of Automaticks or Clock Work; ſhewi how to find the ſizes of all Wheels, or Pinions, accordi to any Number of Teeth, or Leaves aſſign'd to t Wheels, or Pinions. Alſo to find the length of Pend lums, to make any Number of Beats, &c.

Chap. 9. Of Philoſophy; ſhewing how to find t ſtrength of any piece of Timber; the time of the D ſcent of falling Bodies: the time of the Flight Sound, &c.

CHAP. I.

Of Chronology.

PROB. 1.

To find the Golden-Number, for any Year.

The RULE.

TO the Year of our Lord (propos'd) add one, and divide the ſum by 19. the Remainder (not regarding the Quotient) is the Golden Number for that Year. If nought remain, the Golden Number is 19. o for the Year 1708. the Golden Number is 18.

PROB. 2.

To find the Cycle of the Sun, for any Year.

RULE.

To the Year of our Lord (propos'd) add 9, and ivide the Sum by 28, the remainder (not regarding the Quotient) is the Cycle of the Sun. If nought remain, e Circle of the Sun is 28.

Note 1. That the Golden-Number, and Cycle of e Sun, are the ſame both in the Engliſh and Foreign ccompt.

2. That they always begin the Firſt of *January.*

PROB. 3.

find the Epact, for any Year, both in the Engliſh and Foreign Accompt.

Firſt, for the Engliſh Accompt.

Firſt find the Golden Number (by **Prob.** 1.) for the ear propos'd; then multiply the Golden-Number by , and divide the Product by 30, and the Remainder ot regarding the Quotient) is the Epact, according the Engliſh Accompt.

Or more eaſily thus.

Divide the Golden-Number (for the Year propos'd) by 3, and if $\left\{\begin{matrix}0\\1\\2\end{matrix}\right\}$ remain, the Epact $\left\{\begin{matrix}\text{the ſame as}\\\text{10 more than}\\\text{20 more than}\end{matrix}\right\}$ the Golden-Number; but if exceed 30, what remains is the Epact.

Secondly, for the Foreign Accompt.

Having found the Epact according to the Engliſh Accompt; ſubtract 11 therefrom, (adding 30 if Subtractio cannot otherwiſe be made) and what remains is th Epact according to the Foreign Accompt. If 0 remai the Epact is 0. If the Engliſh Epact be leſs than 1 add 30 to it, and then Subtract as before.

Note 1. The Epact always begins on the firſt of *Marc*

2. Mr. *Wing* (in his Ephemerides) is under a gran Miſtake; (either out of *Ignorance*, or rather *Careleſne* for I think ſuch a Man muſt needs know better;) fo ever ſince the Year 1700, he always makes the Epact, the Foreign Accompt, one more than it ſhould be, *e. g.* th Year 1705, he makes the Epact in the Engliſh Accompt 1 (which is right) & in the Foreign Accompt 5, which ſhou be but 4. Whence he Calculates all the Moveable Fea (in the Foreign Accompt) falſe; and what is wor (and indeed ridiculous,) he makes all thoſe Moveab Feaſts (in the Foreign Accompt) which ſhould fall o the *Sunday*, as *Shrove-Sunday*, *Eaſter-Day*, *Rogation-Su day*, *White-Sunday*, *Advent-Sunday*, &c.) to fall on t *Saturday*. So that here the Old Proverb is Verify *Ad Græcas Calendas, two Sundays come together*, to D in *France*, &c. to Morrow in *England*. This is much is reported of Parſon *Zachary*, ſometime Miniſter of *D lington* in *Suſſex*; next Year (ſays he) being Leap-Yea *Eaſter-Day* will fall upon the *Monday*.

I have not inſerted *this* out of any Envy to the A

th

thor, (for the Gentleman is unknown to me;) but to let the World ſee, how eaſy it is for us to be impoſ'd upon, in things we underſtand not. Nevertheleſs, if he only had been Guilty of this Error, I had held my Peace, ſince *Humanum eſt Errare*: But I may add, that moſt of our Annual Writers (I fear out of Ignorance) have (to my Knowledge) for ſeveral Years, been guilty of the ſame Error, of making thoſe Days above mention'd, to fall on the *Saturday*, and well they may do ſo, for I find they tranſcribe from him *A la voléé*, his very Errors, but I ſhall leave this tedious Digreſſion, and proceed to

PROB. 4.

To find the Roman Indiction for any Year.

The RULE.

To the Year of our Lord (propos'd) add 3, Divide the Sum by 15, the remainder (not regarding the Quotient) is the Roman Indiction. This (though commonly inſerted in Almanacks) is now of no uſe, I think I am ſure to us; and therefore I ſhall ſay no more of it.

PROB. 5.

To find whether any Year be Leap-Year, or what Year paſt.

The RULE.

Divide the Year of our Lord (propoſ'd) by 4, and the Remainder (not regarding the Quotient) will ſhew what you want to know. For if nothing remain it is Leap-Year; if 1, 2, or 3, remain, it is the firſt, ſecond or third Year after Leap-Year. So the Year 1705 was the firſt after Leap-Year.

PROB. 6.

To find the Dominical Letter for any Year, both in the English and Foreign Accompt.

For the Engliſh Accompt.

Divide the Year of our Lord (propos'd) by 4, and add the Quotient (not regarding the Remainder) to the Year propos'd, and to their Sum add 4; then divide this laſt Sum by 7, (not regarding the Quotient, but) Noting the remainder; for the Complement of this Remainder to 7, ſhall ſhew the Number of the Letter, reckoning, A 1, B 2, C 3, D 4, &c.

Note. If there be no Remainder when you Divide the Year by 4, that then it is Leap-Year, and conſequently there are two Dominical-Letters that Year; whereof this Rule find the *Laſt*; the *Firſt* is the next Letter in the Order there mention'd, except the laſt Letter be found to be G, and then the firſt Letter will be A.

Otherwiſe,

Firſt find the Cycle of the Sun for the Year propos'd, by Prob. 2, then to the Cycle of the Sun add 3, and divide the Sum by 4; add the Quotient (not regarding the Remainder) to the Cycle of the Sun, and divide this Sum by 7, (not regarding the Quotient, but) Noting the *Remainder*, for that will ſhew the Letter, if you count them in this Order, G 1, F 2, E 3, D 4, &c.

Note 1. If when you divide by 7, nothing remain, 7 is ſuppoſed to remain, and the Letter is A.

2. If when you divide by 4, nothing remains, it is Leap-Year; and conſequently there are two Dominical Letters, of which this Rule finds the *Laſt*; the *Firſt* is the next in the order of the Alphabet, except the laſt be G, and then the firſt is A. *Example*, by either of theſe ways the Dominical Letter (according to the Engliſh Accompt) for the Year 1705, will be found to be G.

For the Foreign Accompt.

Having found the Dominical Letter according to the Engliſh Accompt; find the Number of the Letter according to the Order of the Alphabet, (*viz.* A 1, B 2, &c.)

&c.) and Subtract three therefrom; ſo the Remainder will ſhew the Dominical Letter in the Foreign Accompt. Thus for the Yeer 1705, the Dominical Letter (in the Foreign Accompt) will be D. But

Note 1. If in Subtraction nothing remain, 7 is ſuppos'd to remain, and the Dominical Letter is G.

2. That this Rule finds the Dominical Letter (in the Foreign Accompt) till the Year 1800, for which Year, and ſo forward till the Year 1900, there muſt be but one Subtracted. The Reaſon is, becauſe every 100th Year, for 300 Years together, (but not the 4th) they omit the Leap-Year, *viz.* in the Year 1700, 1800, and 1900, they omit the Leap-Year; but not in the Year 2000.

3. The Dominical-Letter (in both Accompts) changes the firſt Day of *January*.

4. That when 'tis Leap-Year in one Accompt, 'tis alſo in the other; except where the Foreigners omit the Leap-Year, as was ſhewn in the ſecond Note.

5. And when 'tis Leap-Year, there are two Dominical Letters, the firſt of which is uſed till *St. Mathias*'s Day, (the 25 of *Febr.*) and the other from thence to the end of the Year.

PROB. 7.

To find the Number of Direction, for any Year, both in the Engliſh and Foreign Accompt.

Tho' Mr. *Wing*, Mr. *Leybourn*, and Mr. *Salmon* affirm, That this Problem cannot be ſolved by Arithmetick; yet I ſhall ſhew that it may: but I confeſs it coſt me ſome time and ſtudy to diſcover the Method of it; which is thus,

For the Engliſh Accompt.

Firſt find the Epact (by Prob. 3.) for the Year propos'd. Then Subtract the *Epact* from 26, (adding 30 if Subtraction cannot otherwiſe be made,) noteing the Remainder, which I will call the *Fixed Number*. Then divide the Epact by 7, (not regarding the Quotient, but) Noteing the Remainder, (where Note, if nothing remain, the remainder muſt be accounted 7,) and take its Complement to 8. This Complement I will call the *Subtrahend* or Number to be Subtracted. Then (having found the Dominical Letter by Prob. 6.) Subtract this *Subtrahend* from the Number of the *Dominical-Letter*, (reckoning, A 1, B 2, C 3, &c.) and the Remainder added to the *Fixed Number*, gives the *Number of Direction*.

Note 1. If the Subtrahend be greater than the Number of the Dominical Letter, you muſt add 7 to the Number of the Dominical Letter) that ſo Subtraction may be made.

2. That, if (in Subtracting the Subtrahend from the Number of the Dominical Letter,) nothing remain, the Remainder muſt be accounted 7.

3. That when the *Epact* is 28, you muſt add two to the *Subtrahend*, and when it is 29, you muſt Subtract from it, and ſo the Sum, or Remainder will be the true Subtrahend for thoſe times.

4. That when it is Leap-Year, there being two Dominical-Letters, you muſt make uſe of the laſt o them.

Thus the Number of Direction for the Year 1705 was found to be 18.

For the Foreign Accompt.

Find the Dominical-Letter in the Foreign Accompt by Prob. 6, and then work in all reſpects as in the Engliſh Accompt, only making uſe of the Foreign Dominical-Letter; for the Epact made uſe of muſt b the Engliſh.

Thus the Number of the Direction for the Year 170 was found to be 15.

Thus you may find the Number of Direction in either Accompt, without much trouble; Neverthele it may be found with more eaſe, by the following

TA

TABLE.

Pr.	A	B	C	D	E	F	G
1	19	20	21	22	16	17	18
2	5	6	7	8	9	10	11
3	26	27	28	29	30	24	25
4	19	13	14	15	16	17	18
5	5	6	7	8	2	3	4
6	26	27	21	22	23	24	25
7	12	13	14	15	16	10	11
8	33	34	35	29	30	31	32
9	19	20	21	22	23	24	18
10	12	13	7	8	9	10	11
11	26	27	28	29	30	31	32
12	19	20	21	15	16	17	18
13	5	6	7	8	9	10	4
14	26	27	28	29	23	24	25
15	12	13	14	15	16	17	18
16	5	6	7	1	2	3	4
17	26	20	21	22	23	24	25
18	12	13	14	15	9	10	11
19	33	34	28	29	30	31	32

The Uſe of this Table is very eaſy; thus, Firſt find the Prime or Golden-Number (by Prob. 1.) for the Year propoſ'd. Then find the Dominical Letter in the { Engliſh Foreign } Accompt, if you ſeek the Number of Direction in that Accompt. Then enter this Table with the Prime, in the firſt Column, and the Dominical Letter at the top, and in the common Angle of meeting you have the Number of Direction.

Example. For the Year 1705, the Prime is 15, and the Dominical Letter G, in the Engliſh, and D, in the Foreign Accompt, what is the Number of Direction in each Accompt? Anſ. 18 in the Engliſh, and 15 in the Foreign Accompt.

Note. If it be Leap-Year, you muſt enter the Table with the laſt of the Dominical Letters, becauſe the firſt of them is out of Date the 24th of *February*, and the *Number of Direction*, begins not till 22 of *March*.

PROB. 8.

To find the Movable Feaſts (and Terms) in any Year, in both Accompts.

1. For

1. For the Engliſh Accompt.

Find the *Number of Direction* (for the Year propoſ'd) by Prob. 7. Then add the Number of Direction to … and you have …

to	and you have
Jan. 31.	*Shrove-Sunday.*
Feb. 7.	*Firſt Sunday in Lent.*
May 21.	*Eaſter-Day.*
Apr. 7.	*Eaſter-Term* begins.
Apr. 25.	*Rogation-Sunday.*
Apr. 29.	*Aſcenſion-Day.*
May 3.	*Eaſter-Term* ends.
May 9.	*White-Sunday.*
May 16.	*Trinity-Sunday.*
May 21.	*Trinity-Term* begins.
June 9.	*Trinity-Term* ends.

2. For the Foreign Accompt.

Find the *Number of Direction* (for the Year propoſ'd) in the Foreign Accompt, (by Prob. 7,) and add 7 thereto, rejecting 35 if the Sum amount to above 35. Then add this Number to the Months and Days in the preceding Table; ſo you will have the Moveable-Feaſts in the Foreign-Accompt.

Note 1. That this Method gives the Time of the Moveable-Feaſts, in the { Engliſh / Foreign } Accompt, on ſuch a Day of the { Engliſh / Foreign } Month.

2. That *Advent-Sunday* (in both Accompts) is always the neareſt Sunday to the Feaſt of *St. Andrew*, whether it be before it or after it.

PROB. 9.

To find the Age of the Moon; or the Day of her Full and Change, in any Month of the Year.

Though this cannot be done by the Line of Numbers yet becauſe it ſhews the Uſe of the Epact, I ſhall here ſhew how it may be done; and for the better remembring the Rule, take it in Verſe thus:

Janu. 0, 2, 1, 2, 3, 4, 5, 6,
8, 8, 10, 10, *theſe to the Epact fix,*
The Sum (bate 30) *to the Month Day add,*
Or take from 30, *Age, or Change is had.*

Which is thus explain'd. Add to the Epact for *Jan.* 0, *Feb.* 2, *March* 1, &c. When the Epact is added to any of theſe Numbers, the Sum if it be leſs than 30 or the Exceſs above 30, added to the Day of the Month (rejecting 30, if need be) gives the Age of the Moon that Day; but Subtracted from 30, leaves the Day of the Change in (in or from the beginning of) that Month.

Having found the Day of the Change; if it be
{more / leſs} than 15, {Subtract 15 from it. / Add 15 to it,} ſo the
{Remainder / Sum} ſhall be the Day of the Full Moon in that Month.

PROB. 10.

To find what Day of the Week begins the Year: and conſequently, what Day of the Week begins any Month in the Year.

Divide the preceding Year by 4. and add the Quotient (not regarding the Remainder) to that Year; which Sum divide by 7, (not regarding the Quotient) and the Remainder is the Day of the Week that begins the Year; reckoning *Sunday* 1, *Monday* 2, &c. If nothing remain, the firſt Day of *Jan.* is *Saturday.*

To find the firſt Day of the other Months, take this Diſtick.

Feb. Mar. Apr. May. June.
Add 3, and 3, 6, 1, and 4,
6, 2, 5, 0, 3, and 5 more.
July. Aug. Sept. Octo. Nov. Dec.

Above and below the Figures in theſe Verſes, you have the Months to which the Figures (in the Verſes) refer as 3 to *Feb.* 3 to *March* &c. And the plain meaning of the Rule is, That whatſoever Day of the Week, New-Years Day falls upon; the addition of theſe reſpective Numbers, to the Weekly Number of that Day will ſhew what day of the Week all other Months come in upon, only two Cautions are to be obſerv'd.

1. If the ſum of the Numbers added exceed 7, then 7 is to be abated, and the reſt ſhews the day of the Week.

2. In Leap-Years, you muſt account *March*, and every Month after, to come in one day of the Week later than will appear by theſe Rules.

Hence, and by help of the following Table, you may find the day of the Month at any time, as well as by an Almanack.

5	4	3	2	1	*The Table.*						
29	22	15	8	1	*Su.*	*Mo.*	*Tu.*	*We.*	*Th.*	*Fr.*	*Sa.*
30	23	16	9	2	*Mo.*	*Tu.*	*We.*	*Th.*	*Fr.*	*Sa.*	*Su.*
31	24	17	10	3	*Tu.*	*We.*	*Th.*	*Fr.*	*Sa.*	*Su.*	*Mo.*
0	25	18	11	4	*We.*	*Th.*	*Fr.*	*Sa.*	*Su.*	*Mo.*	*Tu.*
0	26	19	12	5	*Th.*	*Fr.*	*Sa.*	*Su.*	*Mo*	*Su.*	*We.*
0	27	20	13	6	*Fr.*	*Sa.*	*Su.*	*Mo.*	*Tu.*	*We.*	*Th*
0	28	21	14	7	*Sa.*	*Su.*	*Mo.*	*Tu.*	*We.*	*Th.*	*Fr.*

The Uſe of this Table will be plain by the following

Example.

Suppoſe I would know what day of the Month the third *Saturday* of *March* 1705) was: by the former part of this Prob. I find the firſt day of the Month was *Thurſday*; therefore I find *Thurſday* on the top of the Table, and under it (in the ſame Column) I find *Saturday*, againſt which on the Left Hand is 3, 10, 17, 24, 31; which ſhews that they are all *Saturdays*; and 21, being under the Figure 3, at the top of the Table, ſhews the third *Saturday* to be the 17th day.

On the contrary, if you would find what Day of the eek any Day of any Month is, enter the Table on e top, with the Day of the Week that begins the onth; and on the left Side, with the Day of the onth; and at the Angle of meeting is the Day of the eek ſought. This needs no Example.

PROB. 2.

reduce Jewiſh or Planetary Hours into our common equal Hours.

The RULE.

ay, as 12 Hours, is to the length of the $\left\{\begin{array}{l}\text{Day}\\ \text{Night}\end{array}\right\}$ from n $\left\{\begin{array}{l}\text{Riſing to Sun Setting}\\ \text{Setting to Sun Riſing}\end{array}\right\}$; ſo is the Jewiſh or netary Hour propos'd to a 4th. Which added to the e of the Sun $\left\{\begin{array}{l}\text{Riſing,}\\ \text{Setting,}\end{array}\right\}$ if the Jewiſh or Planetary ur by $\left\{\begin{array}{l}\text{Day}\\ \text{Night}\end{array}\right\}$ be given, the Sum is the Anſwer.

Example.

Vhen doth the 5th Jewiſh or Planetary Hour by Day , when the Days are 16 Hours long? Anſw. At 40 . after 10 a Clock in the Forenoon. For as 12 : 16 : : $6\frac{2}{3}$ equal to 6 Ho. 40 Min. which added to 4 Ho. time of Sun-Riſing) gives 10 Hours, 40 Minutes.

CHAP. II.

Of Dioptricks.

PROB. 1.

To find the Abſolute Focus of a Convex-Glaſs.

The RULE.

Expoſe the Glaſs to the Sun, and you ſhall ſee a brig Spot caſt upon the oppoſite Wall; remove the Gl *towards* or *from* the Wall, till you bring that brig Spot into the leaſt Compaſs you can. Then the Di ance from the Glaſs to the Spot being meaſur'd, ſh give you the Abſolute or Solar-Focus of that Glaſs. Th are ſeveral other ways to find the Abſolute Focus; b this being a general Rule for all Convex-Glaſſes, I ſh (for Brevity ſake) wave the reſt.

PROB. 2.

To find the Reſpective Focus of a Convex-Glaſs.

1. When a nigh Object is placed more diſtant fr the Glaſs than the Focus; the Rule for determining Diſtinct-Baſe or Reſpective Focus, is *this.*

As the difference between the Diſtance of the Ob and the Focal length, is the or Focal Length; ſo is Diſtance of the Object from the Glaſs, to the Diſta of the Reſpective Focus or Diſtinct Baſe from the Gla

2. When a nigh Object is placed nearer to the G than the Focus; the Rule for finding the Imagin Focus from the Glaſs.

As the differerce between the Diſtance of the Ob from the Glaſs, and the Glaſs's Focal length, is to the Gl Focal length; ſo is the Diſtance of the Object from the G to the Diſtance of the Imaginary Focus from the Glaſ

3. When a nigh Object is placed in the Focus of Glaſs; the diſtinct Baſe or Reſpective Focus will b the ſame Diſtance on the other Side of the Glaſs.

PROB. 3.

To find the Abſolute-Virtual Focus (or Point of Diverg in Concave Glaſſes expos'd to Parallel Rays.

The RULE.

As the Sum of the Radij of both Concavitie to the Radius of either Concavity; ſo is the double ius of the other Concavity, to the diſtance of the Ab- lute Virtual Focus from the Glaſs.

PROB. 4.

o find the Reſpective Virtual Focus (or Point of Divergency) in Concave-Glaſſes, expos'd to converging Rays; when the Point *to which the Ray directly Converges, is diſtant from the Glaſs, more than the Abſolute Virtual Focus in Parallel Rays.*

The RULE.

As the difference between the diſtance of this Point om the Glaſs, and the diſtance of the Abſolute Virtu- Focus from the Glaſs, is to the Diſtance of the Ab- lute Virtual Focus; ſo is the diſtance of this Point of onvergency from the Glaſs, to the Diſtance of the Re- ctive Virtual Focus of this Converging Ray.

PROB. 5.

find the Reſpective Focus (or Point where the Refracted Ray croſſes the Axis) in concave Glaſſes, expos'd to converging Rays; when the Point *to which the Ray Converges, is nigher to the Glaſs, than the Abſolute Virtual Focus of Parallel Rays.*

The RULE.

As the Exceſs of the Virtual Focal length, above the *ſtance* of this Point of Convergency from the Glaſs, is the Virtual Focal length; ſo is the Diſtance of this Point Convergency from the Glaſs, to the diſtance of the re- ctive Focus or Point where this Ray croſſes the Axis.

PROB. 6.

find the Reſpective Virtual Focus or Point of Divergency, in Concave-Glaſſes expos'd to Diverging Rays.

The RULE.

As the Sum of the Diſtance of the Object from the Glaſs, the Glaſſes abſolute Virtual Focal length, is to theGlaſſes abſoluteVirtual Focal length; ſo is theDiſtan of the Object from the Glaſs, to the Diſtance of t reſpective Virtual Focus, (or Point of Divergency) fro the Glaſs.

Note. That by *Focus* or *Virtual Focus*, I mean t abſolute Focus, or abſolute Virtual Focus, made by P rallel Rays falling in a Convex, or Concave-Glaſs.

PROB. 7.

A General Rule, to find the Focus, either Real or Virtual, any Meniſcus Glaſs, the Semidiameters of whoſe Convex and Concavity being unequal.

As the Difference of the Semidiameters, is to either the Semidiameters, whether of the Convexity or Co cavity; ſo is the Diameter of the other Surface, to t Focal length, Real or Virtual.

Note 1. That if the Semidiameter of the Conca Surface be greater than the Semidiameter of the Conve the Glaſs has a real Focus. But, ———

2. If the Semidiameter of the Concave, be leſs th the Semidiameter of the Convex, the Glaſs has only Virtual Focus.

3. That if both the Superficies have the ſame Diam ter, the Ray that falls thereon Parallel to the Axis, af its paſſing the Glaſs, proceeds again Parallel.

Thus much of *Single* Convex and Concave-Glaſſe Before I treat of *Compound* Glaſſes, I ſhall ſay ſomethi of Plain Glaſſes. Concerning which, Obſerve

1. That a Ray of Light falling Perpendicularly o Plain Glaſs, paſſes through unrefracted: But all inc ned Rays are refracted.

2. That a Ray of light falling inclined on a pl Glaſs, *Kepler* tells us, That under 30 Degrees of Incli tion from Air to Glaſs, the Angle of Refraction is $\frac{1}{3}$ the Inclination; and therefore the Refracted Angle is of the Inclination. Wherefore we lay down the f lowing Proportions, as confirm'd by *Kepler*'s Expe ments, and uſually retain'd by moſt Optick Writers.

PRO

PROB. 8.

To find the Refracted Angle, of a Ray proceding from Air to (a Plain) Glaſs.

The RULE.

As 3 to 2; ſo is the Angle of Inclination, to the Refracted Angle.

PROB. 9.

To find the Angle of Refraction, of a Ray proceeding from Air to (a Plain) Glaſs.

The RULE.

As 3 to 1, ſo is the Angle of Inclination, to the Angle of Refraction.

PROB. 10.

To find the Refracted Angle, of a Ray proceding from (a Plain) Glaſs to Air.

The RULE.

As 2 to 3; ſo is the Angle of Inclination to the Refracted Angle.

PROB. 11.

To find the Angle of Refraction, of a Ray proceeding from (a Plain) Glaſs to Air.

The RULE.

As 1 to 3; ſo is the Angle of Inclination, to the Angle of Refraction.

But the Learned Sir *Iſaac Newton* diſcovered by moſt accurate Experiments, that theſe Proportions of *Kepler* (laid down in Prob. 8, 9, 10, and 11,) were not ſufficiently exact: For *Des Cartes* firſt found, That Refractions were not to be meaſured by the Proportion of Angles, but by the Proportion of Sines; (See his Dioptricks, *Cap.* 2. *Sect.* 7.) and therefore Sir *Iſaac Newton* apply'd himſelf to diſcover the Proportion of the Sines; and lays down theſe following

PROB. 12.

To ſolve the eigth Problem more exactly.

The RULE.

As 3000 to 193 (or nearly, as 14 to 9;) ſo is the Sine of the Angle of Inclination, to the Sine of the Refracted Angle.

PROB. 13.

To ſolve the 9th Problem more exactly.

The RULE.

As 300 to 193; ſo is the Sine of the Angle of Inclination, to the Sine of the Angle of Refraction.

PROB. 14.

To ſolve the tenth Problem more exactly.

The RULE.

As 193 to 300; (or nearly, as 9 to 14;) ſo is the Sine of the Angle of Inclination, to the Sine of the Refracted Angle.

PROB. 15.

To ſolve the eleventh Problem more exactly.

The RULE.

As 107 to 300; ſo is the Sine of the Angle of Inclination, to the Sine of Angle of Refraction.

I come now to treat of Compound Glaſſes.

PROB. 16.

The Focal lengths of 2 Convex-Glaſſes being given, the longer being placed before the ſhorter, at any given Diſtance leſs than the longer; To find the Diſtance of the Compound Focus (or Diſtinct Baſe) from the ſhorter Glaſs.

The RULE.

As the Focal length of the ſhorter Glaſs, added to the

Difference between the Focal length of the longer and the Glaſs's Diſtance, is to the Difference between the Focal length of the longer, and the Glaſſes Diſtance; ſo is the Focal length of the ſhorter Glaſs, to the Diſtance of the Compound Focus (or diſtinct Baſe) from the ſhorter Glaſs.

PROB. 17.

A Convex-Glaſs being given, with a Concave of a larger Sphere, the Concave being placed behind the Convex, at any Diſtance leſs than the Focal length of the Convex: To *find the place of the Compound Focus (or diſtinct Baſe) of theſe two Glaſſes.*

The RULE.

From the Focal length of the Convex, ſubtract the Glaſſes Diſtance, mark the difference. Then ſay, as the Exceſs of the Focal length of the Concave above this difference is to the Focal length of the Concave; ſo is this Difference, to the Diſtance of the Compound Focus (or diſtinct Baſe) from the Concave.

PROB. 18.

The Focus's of a Convex and of a Concave Glaſs being given, and the Concave placed towards the Object, diſtant from the Convex, ſo that the Sum of the Concave's Focal length and Glaſs's Diſtance may be greater than the Focal length of the Convex, and this Diſtance of the Glaſſes being given alſo, to find the Diſtance of the Compound Focus (or Diſtinct Baſe) from the Concave.

The RULE.

From the Sum of the Concave's Focal length and Diſtance of the Glaſſes, ſubtract the Focal length of the Convex, mark the Difference. Then ſay,

As this Difference, is to the Focal length of the Convex; ſo is the Sum of the Concave's Focal length and Glaſs's Diſtance, to the Diſtance of the Compound Focus from the Convex.

PROB. 19.

To find how many times the apparent Diameter of an Object is magnify'd by a Teleſcope, conſiſting of a Convex Object Glaſs, and a Convex Eye-Glaſs.

The

The RULE.

Divide the Focal length of the Object-Glaſs by the Focal length of the Eye-Glaſs, the Quotient is the Anſwer. For, as the Focal length of the Object-Glaſs, is to the Focal length of the Eye-Glaſs; ſo is the apparent Diameter of an Object to the bare Eye, to its apparent Diameter through ſuch a Teleſcope.

Example.

A Teleſcope conſiſting of a 12 Feet Object-Glaſs, and a 3 Inch Eye-Glaſs, will magnify 48 times, or make the Object appear 48 times bigger than it does to the bare Eye.

PROB. 20.

To find the Angle receiv'd by a Teleſcope of the foregoing Combination.

The RULE.

As the Diſtance between the Object-Glaſs and the Eye-Glaſs, is to half the breadth of the Eye-Glaſs; ſo is Radius, to the Tangent of half the Angle receiv'd.

PROB. 21.

To find the Diameter of the Image of an Object projected in the diſtinct Baſe of a Convex-Glaſs.

The RULE.

Firſt find the reſpective Focus of the Glaſs, by Prob. 2. Then ſay, as the Diſtance of the Object from the Glaſs, is to the Diſtance of the Image from the Glaſs, (which Image is always in the reſpective Focus;) ſo is the Diameter of the Object, to the Diameter of the Image.

PROB. 22.

To find how many times the apparent Diameter of an Object is magnify'd by a ſingle Microſcope.

The RULE.

Divide 8 Inches, by the Focal length of the Glaſs, the Quotient is the Anſwer.

PROB. 23.

To find how many times the apparent Diameter of an Object is magnify'd by a ſingle Microſcope.

Th

The RULE.

Firſt find how many times the Object is magnify'd in the diſtinct Baſe, by Prob. 21. Then find (by Prob. 22.) how many times of the Image is magnify'd by the Eye-Glaſs; Multiply one Magnification by the other, the Product is the Anſwer.

CHAP. III.

Of Gunnery.

PROB. 1.

The Diameter and Weight of one piece of Ordnance being given; To find the Weight of another Piece of Ordnance (of the ſame Metal and Shape,) Whoſe Diameter is alſo given.

The RULE.

Say, by Triplicate Proportion, (See Book 1. Chap. 16.) As the Diameter of the Piece whoſe weight is known, is to the Diameter of the Piece whoſe weight is ſought; ſo is the Weight known, to the weight ſought.

PROB. 2.

Knowing the Diameter and weight of a Braſs, or Iron, Piece of Ordnance; to find the Weight of an Iron, or Braſs, Piece of the ſame ſhape, whoſe Diameter is alſo given.

The RULE.

Firſt find the Weight (by Prob. 1.) as if it were the ſame Metal with that whoſe weight is given. Then, if the weight of a Braſs, or Iron, Piece be ſought; ſay, As $\left\{\begin{matrix}16:18::\\18:16::\end{matrix}\right\}$ ſo is the Weight found, to the Weight ſought.

PROB. 3.

To find the Quantity of Powder for the Charge of any well Fortify'd Gun, either Braſs or Iron, the Weight of the Gun being given.

Note 1. That a Gun is ſaid to be well Fortify'd, when the Thickneſs of the Metal at the Touch-hole, is equal to the Diameter of the Bore. 2.

2. That in Iron, or Braſs Guns, Gunners allow 3, or 4, Ounces of Powder to every Hundred Weight of Metal in the Gun. This being Premis'd, this is

The RULE.

Multiply the weight of the Gun by 3 for Iron, and by 4, for Braſs Guns the Product is the Ounces of Powder for the Charge, which divided by 16 brings it into Pounds.

PROB. 4.

To find the Quantity of Powder, for the Charge of a Gun not truly Bor'd.

The RULE.

Firſt, find (by Prob. 3.) the Quantity of Powder for a Charge, ſuppoſing the Gun to be truly bor'd.

Secondly, Take the Diameter of the Metal of the Piece at the Touch-hole call this the greater Diameter. Alſo, add the Diameter of the Bore, to double the thickneſs of the Metal at the thineſt ſide, call this the leſſer Diameter.

Thirdly, Say, (by Triplicate Proportion) as the Greater Diameter, is to the leſſer Diameter; ſo is the Quantity of Powder (before found) for the true Bore, to the Quantity to be allow'd to the falſe Bore.

PROB. 5.

Knowing the Diameter of the Bore of one Gun, and its Charge of Powder: To find the Quantity of Powder, for the Charge of any other Gun, the Diameter of whoſe Bore is alſo given.

The RULE.

1. Say (by Triplicate Proportion) as the Diameter of the Bore of the Gun whoſe Charge is known, is to the Diameter of the Bore of the Gun, whoſe Charge is ſought; ſo is the Charge of Powder known, to the Charge ſought. But, Note, This Rule ſuppoſes the ſame Proportion betwixt the Weight of the two Guns, as betwixt the Diameter of their Bores. And therefore,

2. To find whither they have the ſame Proportion betwixt their Weights, as betwixt the Diameter of their Bores; Work by Prob. 1. thus, — Say, (by Triplicate-Proportion) as the Diameter of the Bore of the Piece, whoſe Charge is given, is to the Diameter of the Bore of the Piece, whoſe Charge is ſought; ſo is the Weight of the former to the Weight of the later. If the Weight of the Gun whoſe Charge is ſought, be the ſame as is found by this Proportion; then the Analogy in the firſt Section of this Problem, finds the Charge of Powder ſought: But if the Weight be not the ſame as is found by this Proportion; then, to find its due Charge, ſay, as the Weight of the Gun, found by this Proportion, is to its true Weight; ſo is the Charge of Powder, found by the Analogy in the firſt Section of this Problem, to the true Charge of Powder ſought.

3. And if there be a ſtronger Powder than the former, by ſuch Proportion (ſuppoſe) as 5 to 2, then to find how much of this ſort will charge a Gun: ſay, as 5 to 2; ſo is the Charge in the firſt ſort, to the Charge in the ſtrongeſt ſort.

PROB. 6.

To find how much of every kind of Metal is contain'd in any Braſs Piece of Ordnance.

'Tis a uſual thing for Gun-Founders, for every 100 Pound of Copper, to put in 10 Pound of Latten, and 8 Pound of pure Tin. Now, ſuppoſe this to be the conſtant Rule for their Mixture, then ſay, as 118, (the Sum of the Parts, 100, 10 and 8) is to $\left\{\begin{array}{l}100;\\ 10;\\ 8;\end{array}\right\}$ ſo is the whole Weight of the Gun, to the Pounds of $\left\{\begin{array}{l}\text{Copper}\\ \text{Latten}\\ \text{Tin}\end{array}\right\}$ contain'd therein.

PROB.

PROB. 7.

To find how much of each Ingredient, is contain'd in any Quantity of Powder.

Powder, in this Age, is commonly made of 12 Parts of Nitre, 3 Parts of Coal, and 2 Parts of Sulphur. Now, ſuppoſing this the conſtant Proportion for the Mixture; then ſay, as 17, (the Sum of the Parts 12, 3 & 2) is to $\left\{\begin{matrix}12;\\3;\\2;\end{matrix}\right\}$ ſo is the whole Weight (in Pounds) of Powder propos'd, to the Pounds of $\left\{\begin{matrix}\text{Nitre}\\\text{Coal}\\\text{Sulphur}\end{matrix}\right\}$ contain'd therein.

PROB. 8.

Knowing the Weight (in Pounds) of an Iron Ball, fit for any Piece of Ordnance, the Periphery of whoſe Breech (in Calibers) is alſo given; To find the Charge of Powder fit for Proof and Service.

The RULE.

As 1, is to the Weight of the Ball in Pounds; ſo is the Periphery of the Breech in Calibers, to a fourth. Again, as 96 (a fix'd Number,) is to 8, or 6, (other fix'd Numbers) ſo is the fourth (laſt found) to the Pounds of Powder for Proof, or Service.

PROB. 9.

To find the Weight of any Iron Bullet; its Diameter being given.

The RULE.

Say, (by Triplicate Proportion) as 4, is to the Diameter in Inches; ſo is 9, to the Weight in Pounds

Otherwiſe,

Say, as 100, is to the Cube of the Diameter in Inches; ſo is 14, to the Weight in Pounds.

PROB.

PROB. 10.

To find the Weight of a Granado Shell.

The RULE.

Firſt find its Weight (by Prob. 9.) as if it were Solid. Then put in a Stick at the Fuſe-hole, and take the Diameter of its Concavity, and find its Weight, (as before) as if it were Solid. Subtract this Weight from the former; ſo the Remainder ſhall be the Weight of the Granado Shell ſought.

PROB. 11.

To find what Quantity of Powder will fill any Granado-Shell, or Cartridge.

It has been often experimented in the *Tower* of *London*, That one Pound of Powder will fill 31.06 Cubical Inches. This being known, the Proportion will be,

As 31.06, is to 1; ſo is the Concavity (in Inches) of any Granado-Shell, or Cartridge, to the Pounds of Powder that will fill it.

PROB. 12.

The Diameter of a Cartridge, and the Pounds of Powder that will load any Piece of Ordnance, being known; To find how high the Cartridge muſt be fill'd.

The RULE.

Firſt find (by Book 2. Chap. 3. Prop. 3.) the Area of the Circle of the Cartridge, in Inches. Then ſay,

As the Area of the Circle in Inches, is to the Pounds of Powder allow'd for loading; ſo is 31.06, to the Depth (in Inches) the Cartridge muſt be fill'd.

PROB. 13.

To find the Horizantal Range of any Piece of Ordnance; its greateſt Range and Elevation being given.

The RULE.

As Radius, is to the Sine of double the Elevation; ſo is the greateſt Range, to the Horizontal Range at that Elevation.

PROB. 14.

To find the greateſt Range of any Piece of Ordnance; its Elevation, and Horizontal Range being given.

The RULE.

As the Sine of double the given Elevation, is to Radius; ſo is the Horizontal Range, to the greateſt Range.

PROB. 15.

Knowing the greateſt Range, and Horizontal Range, of a Piece; To find its Elevation.

The RULE.

As the greateſt Range, is to the Horizontal Range; ſo is Radius, to the Sine of double the Elevation.

The following Table being uſeful in Gunnery; I ſhall with it, put an end to this Chapter.

Names of ſeveral Pieces of Ordnance us'd in *England.*	Guns Wei. in	Len. of the Chaſe	Dia. of the Bore	Weight of the Ball	Weight of Pouder	Greateſt Range
	lb.	Feet.	Inch.	lb.	lb.	Paces.
Rabinet.	120	3	1.25	.75	.5	3769
Falconet.	210	4	2.	1.25	.9	4398
Falcon.	700	6	2.75	2.25	1.1	4797
Minion.	1000	8	3.	4.	2.1	5864
Saker.	1600	9.5	3.5	5.25	4.	5654
Demi-Culverin.	2600	10.	4.5	9.	7.5	4886
Culverin.	4000	11.	5.	15.	10.	4837
Demi-Canon.	6000	11.	6.	27.	14.6	4031
Whole Canon.	7000	12.	7.	47.	21.5	3769
Canon Royal.	8000	12.	8.	63.	27.14	3298
Culverin at *Deal* Caſtle.	—	16.	4.75	—	13.1	7407
Baſilisk at *Dover* Caſtle.	—	23.5	4.6	—	18.	11232

Note. A Musket-Shot (to do Execution) is about 72 Feet or 44 Rods.

CHAP. IV.

Of Military-Architecture or Fortification.

TO keep to my Title, That which in this Chapter, will fall under my cognizance, will be the Solution of this General

PROPOSITION.

To find all the Lines and Angles, of any Regular Fortification, from the Trigon to the Dodecagon; any one of the Lines only been given.

Before I lay down the Rule for ſolving this Propoſition, it may be convenient to premiſe theſe following Particulars, Namely,

1. That this Propoſition comprehends no leſs than 1944, diſtinct Problems; all ſolvable by one Plain, Eaſy, and General Rule hereafter to be laid down.

2. That my Deſign, all along being Brevity, and I now fearing, the Book will ſwell beyond the intended Bulk of a Pocket-Volumn; I ſhall (for the eaſier ſolving of this Problem) lay down the following Table, as being the approv'd Proportions of the moſt eminent Engineers.

3. That the Angles in all Regular Fortifications of the the ſame kind, are the ſame, *e. g.* If the Angles in one Regular Tetragonal Fortification are known, they are alſo known in any other Regular Tetragonal Fortification, for they are the ſame. This being Premis'd, I here lay down.

A TABLE.

Of the Dimenſions, of any Regular Fortification, from the Tetragon to the Dodecagon, the Flanking Angle being 15 Degrees more than half the Angle of the Polygon.

The Names of the Angles.	Tetra.	Penta.	Hexa.	Hept.	Octa.	Nona.	Deca.	Ende.	Dode.
	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.
Angle of the Polygon.	90.00	108.0	120.0	128.34	135.0	140.0	44.0	147.16	150.0
Flanking ∠ of the Bulwark.	60.0	69.0	75.00	79.17	82.30	85.0	87.0	88.38	90.0
Angle of the Shoulder.	105.0	109.30	112.30	114.38	116.15	117.30	118.30	119.19	120.0
Inward Flanking ∠.	15.0	19.30	22.30	24.38	26.15	27.30	28.30	29.19	30.0
Outward Flanking ∠.	156.0	141.0	135.0	130.43	127.30	125.0	123.0	121.0	120.0
∠ Fronting the Flank.	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0
The Names of the Lines.	R. 100	R. 100	R. 100	R. 100	R. 100	R. 100	R. 100	R. 100	R. 100
Curtain.	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
Front of the Bulwark.	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Gorge-Line.	10.77	12.18	13.26	14.12	14.83	15.42	15.92	16.36	16.73
Half Diam. of the inw. Pol.	44.92	56.45	68.52	80.94	93.63	106.49	119.49	132.57	145.80
Side of the inward Pol.	63.53	66.36	68.52	70.24	71 66	72.84	73.85	74.71	75.47
Perpend. of Ditto.	31.76	45.67	59.34	72.90	86.50	100 [illegible]	113.64	127.20	140.83
Half Diam. of the outw. Pol.	67.95	80.63	93.74	107.5	120.50	124.[illegible]2	147.59	161.16	174.83
Side of the outward Polygon.	96.9	94.79	93.74	92.90	92.22	91.07	91.21	90.83	90.50
Perpend. of Ditto.	48.4	65.23	81.18	96.42	111.32	125.93	140.37	154.63	168.87
Distance of the Polygons.	15.26	19.57	21.84	23.52	24.83	25.81	26.72	27.43	28.4
Flank.	9.3	10.22	11.13	11.85	12.44	12.94	13.36	13.72	14.4
Head-Line.	23.2	24.18	22 .22	24.11	26.87	27.53	28.10	28.59	29.3
Shoulder from the Centre.	14.5	15.90	17.31	18.43	19.56	20.13	20.79	21.35	21.85
Second Flank.	8.29	13.12	15.13	16.14	16.77	17.14	17.39	17.56	17.63
Longeſt Line of Defence.	70.64	71.14	71.30	71.42	71.55	71.67	71.77	71.86	71.94

In the upper Part of the Preceeding Table, the firſ Column contains the Names of the Angles; and all th following Columns, ſhew the Quantity of thoſe Angles, in Degrees and Minutes. In the lower Part of th Table, the firſt Column contains the Names of the Line the others ſhew their length, in Rods and Centecima Parts.

Th

This is ſufficient for the Explanation of the Table; only we may here Obſerve, That ſince the Angles of all Regular Fortifications (whether greater or leſs,) of the ſame kind, are equal; it will follow, that 54 of 1944, are always ready ſolv'd, by means of the *former* part of the Table) by the following

General RULE.

As the Number in the Table, reſpecting the *Datum* (or thing given,) is to the *Datum*; ſo is the Number in the Table, reſpecting the *Quæſitum*, to the *Quæſitum* or thing ſought.

Example. Let it be requir'd to make a Regular Tetragonal Fortification, the ſide of whoſe inward Polygon ſhall be 31.765 Rods.

In this Caſe I ſay (from the Table,) As 63.53 : 31.765 : : 42 : 21, the length of the Curtain.

Again, as 63.53 : 31.765 : : 28 : 14. the Front of the Bulwark.

Again, as 63.53 : 31.765 : : 10.75 : 5.385 the Gorge-Line.

By working in the ſame manner, the length of all the Lines in the given Fort, will be found to be, as in the following

TABLE.

	Rods.
The Curtain	21.000
The Front of the Bulwark	14.000
The Gorge-Line	5.385
The ½ Diameter of the inward Polygon	22.460
The Side of the inward Polygon	31.765
The Perpendicular of the inward Polygon	15.882
The ½ Diameter of the outward Polygon	33.975
The ſide of the outward Polygon	48.045
The Perpendicular of the outward Polygon	24 020
The Diſtance of the Polygons	8.140
The Flank	4.015
The Head-Line	11.510
The Diſtance of the Shoulder from the Centre	7.025
The Second Flank	4 145
The longeſt Line of Defence	35.470

The Angles of this Fortification, are to be taken out of the former Part of the foregoing Table, after this manner.

	D. M.
The Angle of the Polygon	90.00
The Flanking Angle of the Bulwark	60.00
The Angle of the Shoulder	105.00
The Inward Flanking Angle	15.00
The Outward Flanking Angle	156.00
The Angle Fronting the Flank	40 00

Thus all the Lines and Angles of this Fortification are found, So that you ſee here was 14 Problems ſolved from that one *Datum*, the ſide of the inward Polygon; and all relating to the Tetragonal Fortification. There may be a like Number relating to each of the other Polygons; which increaſes the Number to 125, all ſolvable from the ſame *Datum*: and there being 15 Lines, each of which may be the *Datum*, it makes up the Number of Problems ſolvable by this Rule, 1890.

'Twere needleſs to give any more Examples of this kind, the thing is it ſelf ſo very plain and eaſy. I ſhall therefore (for this time) here put an end to this Chapter of Fortification, and proceed to

---

CHAP. V.

Of Civil-Architecture.

BY Civil-Architecture, I would be underſtood to mean, that kind of Architecture which relates to the building of Houſes. And *here* what is Pertinent to our Purpoſe, is the Solution of the following Problems.

PROB. 7.

To find the length of the Timber, &c. *of a Square Building, at true Pitch: the breadth of the Houſe being given.*

For the eaſier ſolving of this Problem, take the following Table.

Names

Names of the Timbers, &c.	Feet.
The breadth of the Houſe	20.00
The length of the Rafter	15.00
The length of the Hip	18.02
The length of the Perpendicular	11.18
The Half Diagonal	14.14

In this Table, the breadth of the Houſe being 20 Feet; the length of the Timber, &c. are as is there expreſt. Whence 'tis eaſy to find them in any other Square Frame, by this

RULE.

As 20, is to the breadth (in Feet) of any Square Frame; ſo is the Number (in the Table) againſt any one of the Timber, &c. to the reſpective length of that Timber, &c.

Examp. Let there be given the ſquare Frame of a Houſe, 40 Feet broad; and let the Raſters be deſign'd to be true Pitch, what muſt the length of the Rafters, and Hips of this Building.

To anſwer this Queſtion, I ſay (by the Rule) as 20 : 40 :: 15 : 30, the length of the Rafters. Again, I ſay, as 20 : 40 :: 18.02 : 36.04, the length of the Hips. In the ſame manner, the length of the Perpendicular will be found to be 22.36, and the half Diagonal 28.28. So that you ſee this Problem in 4 Fold, or comprehends 4 Problems.

PROB. 2.

To find the length of the Collar Beams, in any Square Frame, at true Pitch.

The RULE.

As the length of the Rafters (which may be found by Prob. 1.) is to the breadth of the Houſe: ſo is the Diſtance from the top of the Rafters to the Collar-Beam, to the length ſought.

Examp. Let the Frame be 20 Feet wide, the Rafters 15 Feet long, and the Collar-Beams 6 Feet from the top; what muſt their length be? Anſ. 8 Feet. For, as 15 : 20 :: 6 : 8.

PROB.

PROB. 3.

To find the length of the Purloyns, in a Square-Frame, Hipt at one end, or both ends, the Rafters being true Pitch.

The RULE.

Firſt find the length of the Rafters, by Prob. 1. Then ſay, as the length of the Rafter, is to the breadth of the Houſe; ſo is the deſign'd Diſtance of the Purloyn from the top of the Rafter, to a 4th. Then, if the Houſe be Hipt but at one end, or at both ends, ſubtract the $\frac{1}{2}$ or the whole, breadth of the Houſe, from the Remainder; to this remainder add the 4th, or double the 4th Proportional found, their Sum ſhall be the length of the Purloyn ſought.

PROB. 4.

To find the length of the Rafters, in a Square Frame at any Pitch.

Before I give the Rule to ſolve this Problem, it may be neceſſary to Note, That the breadth of the Houſe is always given; and the length of the Rafter, or Height of the Perpendicular, is next reſolved on; ſo that if one of them be ſought, the other is (always) known by Aſſumption. This being premis'd, the Prob. may be ſolv'd by this

RULE.

To the Square of half the breadth of the Houſe, add the Square of the Perpendicular; their Sum is the Square of the Rafters length. Therefore, the Square Root being extracted, gives you the length of the Rafter, ſought.

PROB. 5.

The Rafters length being given; To find the Perpendicular, in any Square Frame.

Sometimes, (as I noted above) the length of the Rafters are aſſign'd, and then the Perpendicular muſt be found; which may be done by this

RULE.

RULE.

From the Square of the Rafter's length, ſubtract the Square of half the breadth of the Houſe; the Square Root of the Remainder is the Perpendicular ſought.

PROB. 6.

To find the half Diagonal (or diſtance from the Corner to the King-Poſt) in any Square Frame.

The RULE.

Square the half breadth of the Houſe, which Multiply by two, the Square Root of the Product, is the half Diagonal ſought.

PROB. 7.

To find the length of the Hips, in a Square Frame at any Pitch.

The RULE.

Firſt find the length of the Rafters, by Prob. 4. Then to the Square of the Rafters length, add the Square of the half breath of the Houſe; the Square Root of the Sum is the length of the Hip.

Otherwiſe,

Firſt find the half Diagonal, by Prob. 6. Then, to the Square of the half Diagonal, add the Square of the Perpendicular; the Square Root of the Sum, is the length of the Hip.

PROB. 8.

To find the length of the Rafters, in a Bevel Frame, at any Pitch.

The RULE.

To the ſquare of the half breadth of the Houſe (taken Perpendicularly, and not according to the Beveling,) add the Square of the Perpendicular; the Square Root of the Sum, is the length of the Rafter.

PROB. 9.

To find the Perpendicular, in a Bevel-Frame, the length of the Rafters being given.

The RULE.

From the Square of the Rafters length Subtract the Square of the half breadth of the Houſe, (taken as in

Prob. 8.) the Square Root of the remainder is the Perpendicular.

PROB. 10.

To find the half Diagonals, in a Bevel Frame.

In a Bevel Frame, the half Diagonals are unequal; to find them this is

The RULE.

Conſider the Bevelling (*i. e.* how much the Bevelling makes the Frame longer than the Square from the ſhorteſt Corner, and take the half thereof. Let this half be added to, or Subtracted from, the half breadth of the Frame, (taken according to the Bevelling) noting the Sum, or Remainder; For, if to the Square of this Sum, or Remainder, you add the Square of half the breadth of the Frame, (taken Perpendicularly) the ſquare Root of the Sum ſhall give you the longer, or ſhorter, Diagonal ſought.

PROB. 11.

To find the Length of the Hips, in a Bevel Frame.

The RULE.

Firſt find the length of the Rafter, by Prob. 8. Then add, or Subtract, half the Bevelling to, or from, the half breadth of the Frame, (taken according to the Bevelling) and to the Square of the Sum, or Remainder, add the Square of the Rafters length; the Square Root of the Sum, is the longer, or ſhorter Hip.

Otherwiſe,

Firſt find the half Diagonal by Prob. 10. Then, to the Square of the Perpendicular, add the Square of the longer or ſhorter half Diagonal; the Square Root of the Sum is the longer, or ſhorter Hip.

PROB. 12.

To find the length of the Rafters, in a Taper Frame, being broader at one end than at the other.

In this Caſe the Perpendicular is the ſame throughout the Roof, but the length of the Rafters are unequal: Therefore, to find the length of each pair of Rafters, the breadth of the Houſe muſt be taken betwixt their Feet; and then the Operation is the ſame as in Prob. 4.

Note 1. That to the lengths of Timber found by theſe Rules, you muſt add ſufficient length, for the Feet of the Rafters, and Tenons of the Collar-Beams, *&c.*

2. That the length of Sleepers, in all Roofs, are the ſame as the Hips: A Sleeper being the ſame in the *middle* of a Roof, as a Hip at the *End*.

3. That 'tis difficult to find the Diagonals, and Hips, in Frames Taper and Bevelling, without Sines and Tangents, (for I perceive that Mr. *Brown*, in his Appendix to *Scamozzi's Architecture*, goes upon wrong Principles,) and therefore I ſhall at this time wave it.

CHAP. VI.

Of Nautical Architecture.

BY Nautical Architecture, I mean that kind of Architecture, that relates to the Building of Ships. This being premis'd, I proceed to

PROB. 1.

By the Mould and Burthen of one Ship known, to build another Ship of the ſame Mould, of any aſſign'd Burthen, greater, or leſs.

The RULE.

Say, by Sub-Triplicate Proportion, (See Book 1. Chap. 16. §. 2.) As the Burthen of the Ship, the lengths of whoſe Timber are known, is to the Burthen of the Ship, the lengths of whoſe Timber are ſought; ſo is the length of each particular Timber known, to their length ſought.

Examp. {1, 2, 3,
4, 5, 6.

Suppoſe a Ship of 100 Tun, be 44 Feet long by the Keel, 20 Feet broad at the Midſhip-Beam, and 9 Feet deep in the Hold; and do rack it with the Stem forward 13 Feet, and offward 7 Feet: What muſt be the length by the Keel, breadth at the Beam, and depth in the Hold; and what the Rack forward, and offward, in a Ship of 200 Tun Burthen.

Anſwer. In this Caſe, (working by the Rule above mention'd) the Extent to $\frac{1}{3}$ of the Diſtance betwixt 100 and 200, will reach from the Dimenſions given, to thoſe ſought. Thus you will find, that for a Ship of 200 Tuns Burthen, of the ſame Mould with that propoſed.

The length of the Keel, muſt be 55.44 Feet. *i. e.* 55 Feet, and about $5\frac{1}{4}$ Inches.

The breadth at the Midſhip Beam, muſt be 25.2 Feet *i. e.* 25 Feet, $2\frac{3}{8}$ Inches.

The Depth in the Hold, muſt be 11.34 Feet, *i. e.* 11 Feet and about 4 Inches.

The Rack forward muſt be 16.38 Feet, *i. e.* 16 Feet, $4\frac{1}{2}$ Inches.

The Rack offwards, muſt be 8.82 Feet, *i. e.* 8 Feet, $9\frac{3}{4}$ Inches.

'Twere needleſs to Multiply Examples; thoſe already given being ſufficient, to make the Rule intelligible to the meaneſt Capacity: Beſides the Reader will find one Example more of this kind, in Book 1. Chap. 16. §. 2. Example 6.

PROB. 2.

By the Mould and Burthen of one Ship; To find the Burthen of another Ship of the ſame Mould.

The RULE.

Say, by Triplicate proportion (See Book 1 Chap. 16.) As the length of the Keel, (or breadth at the Beam, or depth in the Hold,) of the Ship whoſe Burthen is known, is to the length of the Keel, (or, *&c.*) of the Ship whoſe Burthen is ſought; ſo is the Burthen of the Ship known, to the Burthen of the Ship ſought.

Example.

If a Ship whoſe Burthen is 300 Tun, be 75 Feet in the Keel; What ſhall be the Burthen of another Ship, (of the ſame Mould) whoſe Keel is 100 Feet? Anſw. 713 Tun. For the Extent from 75 to 100 will reach (being tripl'd) from 300 to 713.

PROB. 3.

To find the length of the Main-Maſt.

The RULE.

As 5, is to 12; ſo is the Breadth of the Ship at the Beam, to the length of the Main-Maſt.

Example. If the breadth of a Ship at the middle Beam, be 30 Feet; What muſt be the Length of the Main-Maſt? Anſw. 72 Feet.

PROB. 4.

To find the length of the Fore-Maſt.

The RULE.

Firſt find the length of the Main-Maſt, by Prob. 3. Then ſay, as 5, is to 4; ſo is the length of the Main-Maſt, to the length of the Fore Maſt.

Example If the breadth of a Ship at the Beam, be 30 Feet; What muſt be the length of the Fore-Maſt? Anſ. 57.6 Feet, *i. e.* 57 Feet, and about 7 Inches.

PROB. 5.

To find the length of the Mizen-Maſt.

The RULE.

Firſt find the length of the Main-Maſt, by Prob. 3. Then ſay, as 2, is to 1; ſo is the length of the Main-Maſt, to the length of the Mizen-Maſt.

Example. If the breadth of a Ship at the Beam, be 30 Feet; What muſt the length of the Mizen-Maſt? Anſ. 36 Feet.

PROB. 6.

To find the length of the Bolt-Split.

The RULE.

Captain *Smith* (in his Sea-Man's Grammar) tells us that the Bolt-Split muſt always be equal with the Fore-Maſt; but ſurely 'tis a miſtake of the Printer; and perhaps he would ſay, it muſt equal with the Mizen-Maſt; for every one knows, that 'tis nothing near ſo long as the Fore-Maſt.

PROB. 7.

To find the bigneſs of each Maſt.

The RULE.

As 3, is to 1; ſo is the length of each Maſt in Feet to its Diameter or Thickneſs, in Inches.

Example. If the Main Maſt of a Ship be 72 Feet long; how big muſt it be at the lower end? Anſ. 24 Inches Diameter.

PROB. 8.

To find the length of the Main-Yard.

The RULE.

As 6, is to 5; ſo is the length of the Keel, to th the length of the Main-Yard.

Example. If the Ship be 76 Feet at the Keel; Wha shall be the length of the Main-Yard? Anſ. 63 333 Feet *i.e.* 63 Feet and 4 Inches.

PROB. 9.

To find the bigneſs of the Main Yard.

The RULE.

As 4, is to 1; ſo is the length of the Main-Yard, i Feet, to his Diameter or Thickneſs, in Inches. Th needs no Example.

PROB

PROB. 10.

To find the length of the Fore-Yard.

The RULE.

Firſt find the length of the Main Yard, by Prob. 8. Then ſay, as 5, is to 4; ſo is the length of the Main-Yard, to the length of the Fore-Yard.

Note 1. The Mizen-Yard is commonly as long as the Maſt; the Top-Yards, half as long as the Main, and Fore-Yard; the Top-Gallant-Yards half the length of them. But,

2. 'Tis difficult (if not impoſſible) to give exact Arithmetical Proportions, for the building of all ſorts of Ships, and fitting their Maſts, Yards, Cables, Cordage, and Sails; by reaſon their Lengths, Breadths, Depths, Rakes, and Burthens are ſo variable. And let me add, That 'tis the Opinion of Seamen, That no Artiſt can build a Ship, and fit her Maſts, *&c.* ſo truly to Proportion; but upon the Tryal of her Condition, they may be amended, I ſhall therefore (at this time) put an end to this Chapter, with the following

PROB. 11.

To find the Burthen of a Ship, or how many Tuns ſhe will carry by knowing her Length at the Keel, Breadth at the Midſhip-Beam, and Depth in the Hold.

The RULE.

Say, (1) As 1, is to the Length of the Keel; ſo is the Breadth at the Midſhip-Beam, to a 4th. (2.) As 1, is to this 4th; ſo is the depth in the Hold, to a 7th. (3.) As 95, (for Merchant Ships) is to 1, ſo is this 7th, to the Ships Burthen ſought. But for ſhips of War, (where there is an allowance for Guns, Anchors, Cables, Maſts, Sails, *&c.* which are all a Burthen, but no Tunnage; the firſt Term of the third Analogy muſt be 100.

This is the common Rule; but not exact; yet it may ſerve to give a gueſs at the Tunnage of a Ship; but there is a great deal more requir'd to give true Meaſure.

Mr. *Hunt* (in his Mathematical Companion) tells us, That the way us'd by Ship-Wrights, (as he receiv'd it from Mr. *Caſtell*, Maſter-Builder at *Deptford*,) is thus,

(1.) As 1, is to the length of the Keel to the Rake; ſo is the extream breadth from Out-ſide to Outſide, to a 4th. (2.) As 1, is to this 4th; ſo is half the breadth, to a 7th. (3.) As 94, (a fix'd Number) is to 1; ſo is this 7th, to the Ships Burthen ſought.

Note. The Dimenſions muſt be all given in Feet.

CHAP. VII.

Of the Mechanic Powers,

PROB. 1.

To find the Force of any Leaver.

The RULE.

As the Length of the ſhorter end from the Fulciment, is to the length of the longer end from the Fulciment; ſo is 1, to the Force or Power of that Leaver.

Example. If a Leaver be 10 Feet long, and the Fulciment or Prop, at two Feet from one end, what will be the Force of that Leaver? Anſw. 4 Fold. (For, as 2, is to 8; ſo is 1 to 4,) *i. e.* one Man by the help of this Leaver thus diſpos'd, may raiſe as great a Weight as 4 Men (or 4 times as much as he himſelf can raiſe without it.

PROB. 2.

To find what Power will be ſufficient, to raiſe a given Weight, with a given Leaver.

The RULE.

As the diſtance of the Power from the Fulciment, i to the Diſtance of the Weight from the Fulciment; ſo i the Weight, to the Power.

Example. If a Leaver be 11 Feet long, and have a Ful ciment at one Foot from one end, and a Weight of a 100 Poun

Pound reſting on the ſhorter end; What Power apply'd to the longer end, will be able to raiſe this Weight? Anſ. A Power equivalent to 100 Pound Weight? (For, as 10, is to 1; ſo is 1000 to 100.) Therefore one Man, by the help of this Leaver, may eaſily raiſe 1000 Pound Weight.

Note. Tho' I here ſay, that 100 Pound at the longer end of this Leaver, will raiſe 1000 Pound at the ſhorter end; yet by the ſtrictneſs of theſe Mechanic Calculations, as appears by Prob. 1.) it is but equal to it in Weight; and therefore you (perhaps) may think it cannot be ſufficient to raiſe it; Nevertheleſs my Aſſertion holds good, namely, that it will be ſufficient to raiſe it; which comes to paſs, by reaſon there is always added to the Power of any Leaver, the weight of the longer end, which is (many times) very conſiderable; as will be evident from Prob. 4.

PROB. 3.

To find what Weight may be raiſed by a given Power, with a given Leaver.

The RULE.

As the Diſtance of the Weight from the Fulciment, is to the Diſtance of the Power from the Fulciment; ſo is the Power, to the Weight.

Example. Thus, with the ſame Leaver, and diſpos'd as was exemplify'd in Prob. 2. one Man or Power equivalent to 100 Pound, will be able to raiſe a Weight of 1000 Pound.

PROB. 4.

To find what Weight muſt be apply'd to the ſhorter end (from the Fulciment) of any Leaver, to make it equiponderate with the longer end. Or, (which is the ſame thing in effect,) To find what Weight the Leaver will raiſe of itſelf.

This cannot be exactly Calculated, unleſs the Leaver be ſuppos'd to be of an equal ſize from end to end:

but if this be granted, then it may be done by this

RULE.

First find the Weight of the whole Leaver, then that of the ſhorter end, by ſaying, as the whole length of the Leaver, is to the whole Weight of it; ſo is the whole length of the ſhorter end, to its Weight. Then Divide the Length of the longer end, by that of the ſhorter end, and reckon the Quotient for the Number of places in a natural Progreſſion. Find the Sum of this Progreſſion, and by it multiply the Weight of the ſhorter end, and from the Product ſubtract the Weight of the ſhorter end, the Remainder is the Weight to be added to the ſhorter end, to make it Equiponderate with the longer end.

Example.

If the Leaver exemplify'd in Prob. 2 and 3, were (of ſeaſon'd Oak,) 2 Inches Diameter; its whole Weight will be about 11 pounds; and the Weight of the ſhorter end about one pound. Therefore (working by the Rule) the Weight to be added to the ſhorter end, to make it equiponderate with the longer end, will be found to be 54 pounds. So that the bare Weight of this Leaver, thus diſpos'd, will ariſe 54 pounds.

The Method of ſolving this Problem, I diſcover'd in *Auguſt*, 1700. I never could ſee it in any Author; But for the Verity of it, I have (beſides Experience) a Demonſtration, grounded on the Principles of the Mechanic Powers.

PROB. 5.

To find the Force of any Axis in Peritrochio, or Wheel.

The RULE.

As the Semidiameter of the Axis or Spindle, is to the Semidiameter of the Wheel; ſo is 1, to the Force of that Wheel.

Example.

If the Diameter of the Axis be 6 Inches, and the Diameter of the Wheel 5 Feet; What will be the Force of that Wheel? Anſ. 10 Fold, (for, as 3, is to 30; ſo is 1 to 10.) or a Power equivalent to one Pound, apply'd to the Circumference of the Wheel, will raiſe a Weight of 10 Pound, apply'd to the Circumference of the Axis, or one Man with this Mechanic Power, will be as ſtrong as 10 without it.

PROB. 6.

To find what Power will be ſufficient, to raiſe a given Weight, with a given Wheel.

The RULE.

As the Semidiameter of the Wheel, is to the Semidiameter of the Axis; ſo is the Weight to the Power.

Example.

What Power will be ſufficient to raiſe a Weight, of 1000 Pound, with the Wheel exemplify'd in Prob. 5. Anſ. A Power equivalent to 100 Pound.

PROB. 7.

To find what Weight may be rais'd, by a given Power, with a given Wheel.

The RULE.

As the Semidiameter of the Axis, is to the Semidiameter of the Wheel; ſo is the Power, to the Weight.

Example.

What Weight may be rais'd by a Power equivalent to a 100 Pound, with the Wheel exemplify'd in Prob. 5. Anſ. 1000 Pound.

PROB

PROB. 8.

To find the Force of any Number of Pulleys.

Before I ſhew how to ſolve this Problem, it may be neceſſary to Premiſe,

1. That one or more Pulleys, whoſe Snatch-Blocks are immovable, neither Increaſe nor Diminiſh the Power. Hence,

2. All the upper Pulleys, do neither Increaſe nor Diminiſh the Power; but ſerve only for Conveniency. This being Premis'd; this Problem may be ſolv'd by theſe

RULES.

1. If the end of the Rope be faſtned to the upper immovable Snatch-Block; then ſay, as 1, is to 2; ſo is the Number of the lower Pulleys, to the Force of thoſe Pulleys. But

2. If the Rope be faſten'd to the movable Snatch-Block; then add one to the 4th Proportional found by the laſt Rule, ſo have you the Force of thoſe Pulleys.

Example.

If there be 4 Pulleys, *viz.* two fixed above and two movable below; What is the force of thoſe Pulleys? Anſ. (if the Rope be fixed to the upper Snatch-Block) 4 fold, (for, as 1, is to 2; ſo is 2 to 4,) or one Man, with this Engine may raiſe a Weight four times as big as he can do without it.

But, if the Rope be faſten'd to the lower Snatch-Block of theſe Pulleys; then will their Force be 5 Fold; or one Man, by their help, ſhall be as ſtrong as five Men without their help.

PROB.

PROB. 9.

To find what Power will be ſufficient to raiſe a given Weight with a given Number of Pulleys.

The RULE.

If the Rope be faſtened to the $\left\{\begin{matrix}\text{upper}\\ \text{lower}\end{matrix}\right\}$ Snatch-Block ſay, as $\left\{\begin{matrix}\text{double the Number of lower Pulleys,}\\ \text{double ——— more by one,}\end{matrix}\right\}$ is to 1; ſo is the Weight, to the Power.

Example $\left\{\begin{matrix}1.\\ 2.\end{matrix}\right.$

What Power will be able to raiſe a Weight of $\left\{\begin{matrix}400\\ 500\end{matrix}\right\}$ Pound, with two lower Pullies, the Rope being faſten'd to the $\left\{\begin{matrix}\text{upper}\\ \text{lower}\end{matrix}\right\}$ Snatch-Block? Anſ. A Power equivalent to 100 Pound. For ———

As $\left\{\begin{matrix}\text{4, is to 1; ſo is 400 to}\\ 4+1=5\text{, is to 1; ſo is 500 to}\end{matrix}\right\}$ 100.

PROB. 10.

To find what Weight may be rais'd by a given Power, with a given Number of Pulleys.

The RULE.

Firſt find the Force of the given Pulleys (by Prob. 8.) then Multiply the given Power thereby; the Product is the Weight that may be rais'd by that Power.

Example $\left\{\begin{matrix}1.\\2.\end{matrix}\right.$

If the Rope be faſtened to the $\left\{\begin{matrix}\text{upper}\\\text{lower}\end{matrix}\right\}$ Snatch-Block; What Weight may be rais'd by a Power equivalent to 100 Pound, with two lower Pulleys? Anſ. $\left\{\begin{matrix}400\\500\end{matrix}\right\}$ Pound.

Note 1. The Increaſe of Power by Pulleys hitherto treated of, proceeds only according to Arithmetical Progreſſion, beginning at $\left\{\begin{matrix}2\\3\end{matrix}\right\}$ if the Rope be faſten'd to the $\left\{\begin{matrix}\text{upper}\\\text{lower}\end{matrix}\right\}$ Snatch-Block: But Pulleys may be diſpos'd in another manner; ſo that the Force of the Power ſhall be Doubled for one Pulley, Quadrupl'd for two, Octupl'd for three; and if there be four Pulleys the Power will equal to 16, and ſo of the reſt. But the particular Method of *this*, I ſhall at preſent pretermit.

PROB. II.

To find the Force of any Wedge.

Some Wedges are made Wedg-wiſe in thickneſs, others in breadth. In the $\left\{\begin{matrix}\text{former}\\\text{latter}\end{matrix}\right\}$ Caſe, ſay as the $\left\{\begin{matrix}\text{Thickneſs}\\\text{Breadth}\end{matrix}\right\}$ of the Wedge at the $\left\{\begin{matrix}\text{thick}\\\text{broad}\end{matrix}\right\}$ end, is to its Length; ſo is 1, to the Force of that Wedge.

Note. This Rule ſuppoſes the Wedges to Terminate in a Point, but ſometimes Wedges of the later kind, do not ſo. In this Caſe, Subtract the breadth of the narrow end, from that of the broad end; then ſay, as that Remainder, is to the length of the Wedge; ſo is 1, to its Force.

Example.

If a Wedge be two Inches broad, and 12 Inches long, terminating in a Point; What is the Force of that Wedge? Anſ 6 Fold, (for, as 2, is to 12; ſo is 1 to 6.) or one Man ſhall be as ſtrong with this Wedge, as 6 Men without it.

Note. The *Power* moving a *Wedge*, is *Percuſſion*; which is a thing that cannot be ſufficiently explain'd in few Words, and therefore I ſhall at preſent omit it.

PROB. 12.

To find the Force of any Skrew.

The RULE.

As the Diſtance of the Helixes or Threads, is to the Circumference of the Circle deſcrib'd by the Handle, or what elſe you will call it) whereby the Skrew is turn'd about; ſo is one, to the Force of that Skrew.

Example.

If the diſtance of the Helixes be $1\frac{1}{2}$ Inch, and the Handle (whereby the Skrew is turn'd about) ſtick out $3\frac{1}{2}$ Feet from the Centre of the Skrew; What is the Force of that Skrew? Anſ. 176 Fold, (for the Circumference of the Circle deſcrib'd by the Handle, will be 22 Feet or 264 Inches, therefore, as 1,5 is to 264; ſo is 1, to 176.) or one Man with this Skrew, will be as ſtrong as 176 Men without it. Or, ſuppoſing the Strength of one Man, but equal to a 100 Weight or 112 Pound, he may (with this Skrew) raiſe a weight (or preſs with a Force) equal to eight Tuns and 16 Hundred Weight; So prodigious is the Force of this Mechanic Powers.

PROB. 13.

To find the Force of (or rather Advantage gain'd by) any Inclining Plain.

The RULE.

As the Perpendicular Height of any Inclining Plain, is to its length; ſo is one, to the Advantage gain'd by that Inclining Plain.

Example.

If the Height an Inclining Plain be 2 Feet, and its Length 8 Feet; What Advantage (in raiſing a Weight) is gain'd thereby? Anſ. A 4 Fold advantage; Or one Man may raiſe a Weight to the top of that Inclining Plain, as eaſily as four Men can raiſe the ſame Weight, to the ſame Height without the Inclining Plain.

PROB. 14.

To find the Height and Length of an Inclining Plain, by the help of which, a given Weight may be raiſ'd to a given Height, by a given Power.

The RULE.

The Height muſt be the ſame with the Height the Weight is to be rais'd. And for the length, ſay, as the given Power, is to the given Weight; ſo is the Height of the Inclining Plain, to its length.

Example.

If it be requir'd to raiſe a Weight of 400 Pound, to the Height of 4 Feet, with a power equivalent to 100 Pound; What muſt be the Height and length of the Inclining Plain, Anſ. The Height muſt be 4 Feet, and the Length 16 Feet.

The Engines of Strength (in Lifting, Preſſing and Drawing,) that have been, or may be contriv'd, from the Compoſition of two or more of theſe Mechanic Powers, are ſo many, that I have not room here, ſo much as to mention them. I ſhall therefore conclude this Chapter with the following

PROB. 15.

To find the Force of any Machine or Engine, compos'd of two or more of theſe Mechanic Powers.

The

The RULE.

Firſt find the Space or Diſtance mov'd by the Power, in the ſame time as the Weight is remov'd any other Space; (which is eaſily found by comparing the ſeveral Parts of the Engin;) then ſay, as the Motion of the Weight, is to the Motion of the Power; ſo is 1, to the Force of that Engin.

Example.

In the Engin commonly call'd the Perpetual Skrew, and Axis in Peritrochio; let the Diameter of the Axis be $3\frac{1}{2}$ Inches, and the Diameter of the Wheel $3\frac{1}{2}$ Feet; let this Wheel have 50 Teeth, and the Skrew to make one Revolution for each Tooth; and let the length of the Handle or Winch, (by which the Skrew is turn'd about) be 14 Inches; What is the Force of this Engin? Anſ. 400 Fold. Or one Man with this Engin, ſhall be as ſtrong as 400 Men without it. For while the Weight is rais'd the ſpace of 11 Inches, (equal to the Circumference of the Axis) the Power (at the Winch) will have mov'd 4400 Inches, (for the Winch makes 50 Revolutions, while the Wheel makes one, and each Revolution of the Winch is 88 Inches;) therefore I ſay, as 11 the Motion of the Weight, is to 4400 the Motion of the Power; ſo is 1, to 4400, the Anſwer to the Queſtion.

CHAP. VIII.

Of Automaticks or Clock-Work.

PROB. $\left\{\begin{matrix}\text{1.}\\ \text{2.}\end{matrix}\right.$

The Diameter of any $\left\{\begin{matrix}\textit{Pinion,}\\ \textit{Wheel,}\end{matrix}\right\}$ *being given, with the Number of its* $\left\{\begin{matrix}\textit{Leaves}\\ \textit{Teeth,}\end{matrix}\right\}$ *and the Number of* $\left\{\begin{matrix}\textit{Teeth}\\ \textit{Leaves}\end{matrix}\right\}$ *in the* $\left\{\begin{matrix}\textit{Weel}\\ \textit{Pinion,}\end{matrix}\right\}$ *that it is to work into, being alſo given; To find the Diameter of that* $\left\{\begin{matrix}\textit{Wheel.}\\ \textit{Pinion.}\end{matrix}\right.$

The Rule. As the $\left\{\begin{array}{l}\text{Leaves}\\ \text{Teeth,}\end{array}\right\}$ of the $\left\{\begin{array}{l}\text{Pinion}\\ \text{Wheel,}\end{array}\right\}$ is to the $\left\{\begin{array}{l}\text{Teeth}\\ \text{Leaves}\end{array}\right\}$ of the $\left\{\begin{array}{l}\text{Wheel ;}\\ \text{or Pinion ;}\end{array}\right\}$ ſo is the Diameter of the $\left\{\begin{array}{l}\text{Pin.}\\ \text{Wh.}\end{array}\right\}$ to the Diameter of the $\left\{\begin{array}{l}\text{Wheel.}\\ \text{Pinion.}\end{array}\right.$

Example.

If the Diameter of a Pinnion, or Wheel be .5 or $\frac{1}{2}$ an Inch, or 4 Inches, and have 5 Leaves, or 40 Teeth; and if it be requir'd to fit to it a Wheel of 40 Teeth, or Pinion of five Leaves; what muſt be the Diameter of that Wheel or Pinion? Anſ. 4 Inches, or .5 of an Inch.

PROB. 13.

To find the Number of Beats made in an Hour, (or Minute &c.) by any Watch.

The RULE.

Divide (the Number of Teeth in) every Wheel, (from the great Wheel or Fuſy, to the Crown Wheel, or Swing Wheel,) by the (number of Leaves in the) Pinion it drives; and multiply all the Quotients one into another continually, and the laſt Product by the Number of Teeth in the Crown (or Swing) Wheel; and multiply this laſt Product by two (for the Pallats;) this laſt Product gives you the Number of Beates in one turn of the great Wheel or Fuſy.

Then divide the Dial-Wheel by the Pinion of Report, and by the Quotient multiply the Number of Beats (but now found) in one Turn of the Hand or 12 Hours: Therefore, dividing that Product by 12, the Quotient is the Beat in an Hour: And if this Quotient be divided by 60, the Quotient will be the Beats in a Minute: And if this laſt Quotient be again Divided by 60 the Quotient will be the Beats in a Second.

Example

Example.

Let there be a Watch of 4 Wheels, whoſe Teeth are according to the following Numbers.

Firſt, The Great Wheel, (Number 55 Teeth) turning the Pinion (Number 5.) fix'd to the Arbor of the ſecond Wheel.

Secondly, The ſecond Wheel, (Number 45,) turning the Pinion (Number 5,) fix'd to the Arbor of the Contrat Wheel.

Thirdly, The Contrat-Wheel,) Number 40,) turning the Pinion (Number 5,) fix'd to the Crown-Wheel.

Fourthly, The Crown Wheel, Number 17, working upon the Pallats, Number 2.

Thus for Watches of 4 Wheels; but for Watches of five Wheels, there will be a third Wheel before the Contrat Wheel.

Fifthly, The Pinion of Report fix'd to the Arbor of the Great Wheel, (Number 4,) turning the Dial-Wheel (Number 36.) which carries the Hand about on the Face in 12 Hours.

Now, let it be requir'd to find how many Beats this Watch makes in an Hour, or a Minute. To anſwer this Queſtion, I work by the Rule, dividing each Wheel by its Pinion, and find the Quotients to the three firſt Wheels (divided by their Pinions) to be 11, 9, 8. theſe multiply'd together produce 792, (which is the Number of Turns of the Crown-Wheel, to one Turn of the Great Wheel;) which being multiplied by 17, (the Number of Teeth in the Crown Wheel, and that Product by two, (the Pallats) produces 26928, (the Beats in one turn of the Great Wheel. (Then, the Dial-Wheel divided by the Pinion of Report, the Quotient is 9, by which I multiply 26928, (the Beats in one turn of the Great Wheel, and the Product is 242352, the Beats in (one turn of the Hand, or) 12 Hours, which being divided by 12, gives 20196, the Beats in an Hour, which being divided by 60, gives 336.6, that is ſomewhat above $336\frac{1}{2}$, the Beats in a Minute.

PROB. 4.

The Beats and Time of a Watch's going, being propos'd; To find what Number of Turns the Fuſy will have.

The RULE.

As the Beats in one Turn of the Great Wheel or Fuſy, (ſuppoſe, as in the laſt Example, 26928,) is to the Beats in one Hour; ſuppoſe as there alſo, 20196,) ſo is the continuance of the Watch's going in Hours, (ſuppoſe 16,) to the Number of the Turns of the Fuſy, (12.)

PROB. 5.

By the Beats, and Turns of the Fuſy; To find how many Hours the Watch will go.

The RULE.

As the Beats in one Hour, (ſuppoſe 20196) is to the Beats in one Turn of the Fuſy; (ſuppoſe 26928) ſo is the Number of the Turns of the Fuſy, (ſuppoſe 12,) to (16,) the continuance of the Watch's going in Hours.

PROB. 6.

By the Turns of the Fuſy, and continuance of the Watch's going in an Hour; To find the Beats in one Turn of the Fuſy.

The RULE.

As the Number of Turns of the Fuſy. (ſuppoſe 12,) is to the continuance of the Watch's going in Hours; (ſuppoſe 16.) ſo are the Beats in an Hour, (ſuppoſe 20196,) to (26928,) the Beats in one Turn of the Fuſy.

PROB. 7.

By the Time of the Watch's going, the Number of Turns of the Fuſy, and the Beats in one Turn of the Fuſy; To find the Beats in an Hour.

The

The RULE.

As the continuance of the Watch's going in Hours, (ſuppoſe 16,) is to the Number of Turns of the Fuſy (ſuppoſe 12,) ſo are the Beats in one Turn of the Fuſy (ſuppoſe 26928,) to 20196,) the Beats in an Hour.

PROB. 8.

By the Beats in one Turn of the Fuſy, and the Beats in an Hour, and the Hours of the Face, (which are always 12, or 24.) To find what Quotient muſt be laid upon the Pinion of Report.

The RULE.

As the Beats in one turn of the Great Wheel or Fuſy; (ſuppoſe 26928,) is to the beats in an Hour (ſuppoſe 20196,) ſo is the Hours of the Face, (ſuppoſe 12,) to (9,) the Quotient of the Hour-Wheel (or Dial-Wheel) divided by the Pinion of Report, *i. e.* the Number of Turns of the Pinion of Report, in one Turn of the Dial-Wheel.

PROB. 9.

Another way to find what Quotient muſt be laid upon the Pinion of Report; by knowing the time of the Watch's going, the Turns of the Fuſy, and the Hours of the Face.

The RULE.

As the Hours of the Watch's going, (ſuppoſe 16,) are to the Turns of the Fuſy (ſuppoſe 12,) ſo are the Hours of the Face, (ſuppoſe 12,) to (9) the Quotient of the Pinion of Report.

PROB. 10.

To find the exact length of a Pendulum, for any Clock, or Watch.

The RULE.

Firſt find (by Prob. 3.) the Number of beats in a Minute. Then ſay, by Duplicate Proportion, (*v.* Book 1. Chap. 15.) As the beats in a Minute, is to 60; ſo is 39.2, to the length of the Pendulum in Inches.

Otherwiſe,

Say, (by the Golden Rule) as the Square of the beats in a Minute, is to (the Square of 60,) 3600; ſo is 39.2, to the length of the Pendulum in Inches.

Example.

If a Watch make 120 beats in a Minute; how long muſt its Pendulum be? Anſ. 9.8 Inches, (*i. e.* ſomewhat above $9\frac{1}{4}$ Inches.) For, as 14400 is to 3600; ſo is 39.2 to 9.8.

PROB. 11.

To find the Beats in a Minute; by knowing the length of the Pendulum.

The RULE.

Say, by Subduplicate Proportion, (*v.* Book 1. Chap. 15.) As the length (in Inches) given, is to 39.2; ſo is 60, to the Beats in a Minute.

Otherwiſe,

Say, (by the Golden Rule,) as the length (in Inches) given, is to 39.2; ſo is (the Square of 60,) 3600, to the Square of the Beats in a Minute.

Therefore, if the length of the Pendulum be propos'd, the Numbers (for the Wheels of the Watch) muſt be ſo adapted, as to make the Number of Beats in a Minute found by this Rule.

PROB. 12.

To Calculate the Striking Part of a Clock.

The RULE.

Though this part conſiſts of many Wheels, and Pinions; yet reſpect need be had only to the Count-Wheel, Striking-Wheel, and Detent-Wheel, which move round in this Proportion. The Count-Wheel commonly moves round once in 12, (ſometimes in 24,) Hours. The Detent-Wheel moves round commonly every ſtroke the Clock Strikes) ſometimebut once in two Strokes.) Hence it follwos,

1. That, as many Pins as are in the Pin-Wheel, ſo many Turns hath the Detent-Wheel to one Turn of the Pin-Wheel. Or, (which is the ſame thing) the Number of Pins in the Pin-Wheel, are equal to the Quotient of that Wheel divided by the Pinion of the Detent-Wheel. But if the Detent-Wheel moves but once round in two Strokes of the Clock, then the ſaid Quotient is but half the Number of Pins.

2. As many Turns of the Pin-Wheel as are requir'd to make the Strokes (which are 78) of 12 Hours, ſo many Turns muſt the Pinion of Report have to turn round the Count-Wheel once. Or thus, divide 78 by the Number of Striking Pins, and the Quotient ſhall be the Quotient of the Pinion of Report. All this is, in caſe the Pinion of Report (as is very common) be fix'd to the Arbor of the Pin-Wheel.

Theſe following Rules will be of great uſe in this part of Calculation, *viz.*

RULE. 1.

As the Number of Turns of the Great Wheel or Fuſy, is to the Days of the Clock's Continuance or going; ſo is (156) the Number of Strokes in 24 Hours, to the Strokes in one Turn of the Great Wheel or Fuſy.

RULE. 2.

As (156.) the Number of Strokes in 24 Hours, is to the Strokes in one Turn of the Fuſy; ſo are the Turns of the Fuſy, to the Days of the Clock's Continuance.

RULE 3.

As the Strokes in one turn of the Fuſy, is to (156,) the Strokes in 24 Hours; ſo is the Days of the Clock's Continuance, to the Number of Turns of the Fuſy.

RULE 4.

As the Number of Strokes in the Clock's Continuance, or in all its Turns of the Fuſy, is to the Turns of the Fuſy; ſo is (78,) the Strokes in 12 Hours, to the Quotient of the Pinion of Report, fix'd to the Arbor of the Great Wheel.

PROB.

PROB. 13.

By knowing what Weight will move the wheels of a Clock, for one time; To find what Weight will be requir'd to make the same Clock go any other time, keeping the ſame Deſcent.

The RULE.

As the time of the Clock's going, given, is to the time requir'd; ſo is the weight given, to the weight ſought.

Example.

Suppoſe a common Clock, that requires a weight of 50 Pounds, to keep it in Motion; and ſuppoſe the Place where the weight deſcends be 20 Feet, and that this Deſcent ſerves for 12 Hours. Let it be requir'd (with the ſame Deſcent of the weight) to make this Clock go 24 Hours, (which may be done by adding a ſingle Pulley to the weight;) what weight (in this Caſe) muſt the Clock have? Anſw. 100 Pound. For, as 12, is to 24; ſo is 50, to 100.

CHAP. IX.

Of Philoſophy.

PROB. 1.

To find the Strength of any Square piece of Timber.

The RULE.

As the length of it in Feet, is to the Square of its thickneſs in Inches, multiply'd by its breadth in Inches, ſo is the Strength (*viz.* how much weight it will bear, when diſpos'd Horizontally, and ſupported by the ends with convenient Blocks or *Fulcra*, and the weight hang'd in the middle) of a piece of Timber (of the ſame kind) one Inch Square, and one Foot long, to the Strength of given piece.

Note 1. That by Thickneſs I here mean that way of the Timber which is to bear the Streſs. Thus, if a piece of Timber (which is broader than 'tis thick) be laid Edge-wiſe, then the breadth of it is accounted the thickneſs; and ſo it will bear a much greater weight, than if the ſame piece were laid the flat way.

2. That this Rule is general for all kind of Timber; if the Strength (*viz.* What weight it will bear) of a piece an Inch Square and a Foot long (of each kind of Timber) be firſt known, or found by Experience.

3. That the Strength of a piece an Inch Square and a Foot long, being known; it muſt be the third Term in the foregoing Analogy.

Example.

Suppoſe the Strength of a piece of Oak, an Inch Square and a Foot long, to be (but) 200 weight, (tho' I am ſure it will be a great deal more;) what will a Joyſt bear, that (lying Edge-wiſe) is 8 Inches thick, and 3 Inches broad, and 10 Feet long? Anſw. 38.4 Hundred weight, or one Tun, and 18.4 Hundred weight.

PROB. 2.

Any heavy Body being propos'd to be let fall from on high; To find how far it will deſcend in any given Time.

The RULE.

Reduce the given Time into Seconds of an Hour; Then ſay, as 1, is to the Square of thoſe Seconds; ſo is 12.5, to the Space or Diſtance (in Feet Engliſh) it will deſcend in that time.

Example.

How far will a falling Body deſcend in one Minute of an Hour? Anſw. 45000 Feet, that is, 120 Feet above 8$\frac{1}{2}$ Engliſh Statute Miles.

PROB. 3.

Any Height being propos'd, from whence a Body is to be let fall; To find how long it will be a falling.

The RULE.

As 12.5, is to the given Height in Feet; ſo is 1, to the Square of the Seconds of the Time that the Body will be a falling.

Example.

How long will a Body be a falling, from the Height of one Engliſh Mile? Anſw. 20.5 Seconds, that is a very little above $\frac{1}{3}$ of a Minute.

PROB. 4.

Any Time being propos'd; To find the Space or Diſtance that a Sound will fly in that Time.

The RULE.

Reduce the given time into the Seconds of an Hour. Then ſay, As 1, is to 1400, or to 84.8484; ſo is the given Time in Seconds, to the Diſtance in Feet, or Perches, that a Sound will fly in that Time.

Otherwiſe,

Without reducing the given Time into Seconds, work thus: If the Time be given, in Minutes or Hours, ſay, as 1, is to 15.9, or to 954.54; ſo is the given time in Minutes, or Hours, to the Diſtance in Engliſh Miles, that a Sound will fly in that time.

Example 1.

How far will Sound fly in a Minute of an Hour? Anſ. 15.9 Miles, that is almoſt 16 Miles.

Example 2.

How far will Sound paſs in an Hour? Anſ. 954.54 Miles *i. e.* ſomewhat above 954 Miles and a half.

PROB.

PROB. 5.

Any Space or Diſtance being propos'd; To find how long Sound will be flying that Diſtance.

The RULE.

If the Space or Diſtance propos'd, exceed not 15 Engliſh Miles; you may ſay, as 1400, or 84.8484, is to 1, ſo is the Diſtance propos'd in Feet, or Perches, to the Time in Seconds, that a Sound will require to fly that Diſtance.

But, if the Diſtance propos'd exceed 15 Miles; you may ſay, as 15.9, or 954.54, is to 1; ſo is the Diſtance propos'd in Miles Engliſh, to the Time in Minutes, or Hours, that a Sound will require to fly that Diſtance.

Example.

How long will Sound be a flying 40 Miles? Anſ. 2.51 Minutes, *i. e.* a little above two Minutes and a half.

Note 1. That this Chapter is wholly new, none of it (to my knowledge, being ever Publiſh'd before.

2. That the Grounds of theſe 5 Philoſophical Problems, (and many more, which to my knowledge were never made Public,) together with a larger Account of them, and many Curioſities relating to them, the Reader may find in my *Philoſophia Practica*, or *Philoſophical Experiments and Obſervations reduced to Practice*; which I may ſhortly preſent the World with, if this find but a kind Reception. And therefore I am unwilling ts anticipate that Treatiſe, by tranſcribing any more Propoſitions from it. But I ſhall at this time let the Reader find

FINIS.

Poſtſcript.

Courteous Reader,

THough in this Treatiſe, I promis'd only, to ſhew how to ſolve all the *Propoſitions* therein contain'd, by *Gunter's-Line*; yet (I have been better than my Word; for) as I have *here* propos'd *them* Analogically, *they* may as well be ſolved by the *Pen*; or by any other *Inſtrument* whereby an Analogy may be wrought; of which kind of Inſtruments there are very many: And therefore *this* Book (being an Epitome of the whole *Practical Mathematicks*) may be a fit Pocket-Companion for *any Man*, of what Degree or Profeſſion ſoever.

BRITISH MUSEUM 30 DEC 60

VALE.

1/6

5,5
5,5

275
275

30,25
5,5

15625
15125

1668,75

6 58
2
1 26 2/6
1 5/16 3
2
20 5/16 78